

**ECOLOGICAL RISK ASSESSMENT  
WHITEWOOD CREEK SITE FIVE YEAR REVIEW  
LEAD, SOUTH DAKOTA**

**July 2002**

Prepared for:

US Environmental Protection Agency  
Region 8  
999 18th Street, Suite 500  
Denver, CO 80202



Prepared by:

Syracuse Research Corporation  
Environmental Science Center - Denver  
999 18th Street, Suite 1975  
Denver, CO 80202



## TABLE OF CONTENTS

EXECUTIVE SUMMARY .....	<a href="#">ES-1</a>
1.0 INTRODUCTION .....	<a href="#">1-1</a>
1.1 Purpose .....	<a href="#">1-1</a>
1.2 Approach .....	<a href="#">1-1</a>
1.3 Organization .....	<a href="#">1-2</a>
2.0 SITE CHARACTERIZATION .....	<a href="#">2-1</a>
2.1 Site Location .....	<a href="#">2-1</a>
2.2 Site Description .....	<a href="#">2-1</a>
2.3 Basis of Potential Concern .....	<a href="#">2-3</a>
2.4 Site Regulatory History .....	<a href="#">2-5</a>
2.5 Site Environmental Setting .....	<a href="#">2-6</a>
2.5.1 Physical Setting .....	<a href="#">2-6</a>
2.5.2 Vegetative Cover .....	<a href="#">2-7</a>
2.5.3 Aquatic Ecology .....	<a href="#">2-8</a>
2.5.4 Terrestrial Ecology .....	<a href="#">2-9</a>
2.5.5 Rare, Endangered and Threatened Species .....	<a href="#">2-9</a>
3.0 PROBLEM FORMULATION .....	<a href="#">3-1</a>
3.1 Summary of Screening Ecological Risk Assessment (SERA) .....	<a href="#">3-1</a>
3.2 Baseline Risk Assessment Site Conceptual Model .....	<a href="#">3-2</a>
3.3 Selection of Terrestrial Indicator Species .....	<a href="#">3-5</a>
3.4 Selection of Chemicals of Potential Concern .....	<a href="#">3-6</a>
3.5 Assessment Endpoints, Testable Hypotheses, and Measurement Endpoints ..	<a href="#">3-7</a>
3.4.1 Stream Viability and Function .....	<a href="#">3-8</a>
3.4.2 Riparian Floodplain Function and Viability .....	<a href="#">3-8</a>
3.4.3 Viability of Insectivorous Wildlife .....	<a href="#">3-9</a>
3.4.4 Viability of Herbivorous/Omnivorous Wildlife .....	<a href="#">3-9</a>
3.4.5 Viability of Carnivorous Wildlife .....	<a href="#">3-9</a>
3.4.6 Viability of Aquatic Insectivorous Wildlife .....	<a href="#">3-9</a>
3.4.7 Viability of Aquatic Piscivorous Wildlife .....	<a href="#">3-10</a>
3.4.8 Viability of Amphibian Community .....	<a href="#">3-10</a>
4.0 INVESTIGATIONS CONDUCTED SINCE THE SERA .....	<a href="#">4-1</a>
4.1 USEPA ERT Field Investigations .....	<a href="#">4-1</a>
4.2 Seep Studies .....	<a href="#">4-4</a>
4.3 Aquatic Community Evaluations .....	<a href="#">4-5</a>
4.4 Terrestrial Community Evaluations .....	<a href="#">4-5</a>

5.0	DATA EVALUATION AND USABILITY	5-1
5.1	Surface Water	5-1
5.2	Sediment	5-3
5.3	Porewater	5-4
5.4	Seeps	5-4
5.5	Soils	5-5
5.6	Biological Tissues	5-6
5.6.1	Benthic Macroinvertebrate Tissue	5-6
5.6.2	Fish Tissue	5-6
5.6.3	Terrestrial Plant Tissue	5-7
5.6.4	Terrestrial Invertebrate (Grasshopper) Tissue	5-7
5.6.5	Soil Invertebrate (Earthworm) Tissue	5-8
5.6.6	Small Mammal Tissue	5-8
5.6.7	Bird Tissue	5-8
6.0	ASSESSMENT OF STREAM VIABILITY AND FUNCTION	6-1
6.1	Chemicals of Potential Concern for Aquatic Receptors	6-1
6.2	Comparison of COPC Concentrations in Site Media to Toxicity Benchmarks	6-1
6.2.1	Surface Water Concentrations Compared to Toxicity Benchmarks	6-2
6.2.2	Sediment Concentrations Compared to Toxicity Benchmarks	6-5
6.2.3	Screening-Level Risks to Fish from Oral Exposure	6-12
6.2.4	Comparison of COPCs in Fish Tissue to Toxicity Benchmarks	6-13
6.3	Site-Specific Sediment Toxicity Tests	6-14
6.4	Assessment of Seep Water Toxicity	6-15
6.4.1	Comparison of Seep Water Concentrations to AWQC Values	6-16
6.4.2	Comparison of Upstream and Downstream Concentrations	6-16
6.4.3	Site-Specific Acute Toxicity to the Fathead Minnow	6-17
6.5	Comparison of the Aquatic Communities to Reference Communities	6-18
6.5.1	Fish Communities	6-19
6.5.2	Benthic Macroinvertebrate Communities	6-21
6.5.3	Periphyton Communities	6-24
7.0	ASSESSMENT OF RIPARIAN FLOODPLAIN FUNCTION AND VIABILITY	7-1
7.1	Chemicals of Potential Concern for Terrestrial Receptors	7-1
7.2	Comparison of COPC Concentrations to Toxicity Benchmarks	7-2
7.2.1	Soil Concentrations Compared to Phytotoxicity Benchmarks	7-2
7.2.2	Seep Water Concentrations Compared to Phytotoxicity Benchmarks	7-4
7.2.3	Soil Concentrations Compared to Benchmarks for Soil Organisms	7-5
7.3	Site-Specific Soil Toxicity Tests	7-7
7.3.1	Site-Specific Soil Toxicity Tests with Plants	7-7
7.3.2	Site-Specific Soil Toxicity Tests with Earthworms	7-10
7.4	Comparison of the Vascular Plant Community to Reference	7-11
7.5	Comparison of Soil Functions to Reference	7-13

8.0	ASSESSMENT OF WILDLIFE VIABILITY .....	<a href="#">8-1</a>
8.1	Chemicals of Potential Concern for Wildlife Receptors .....	<a href="#">8-1</a>
8.2	Representative (Surrogate) Species and Exposure Pathways .....	<a href="#">8-1</a>
8.3	Hazard Quotient Approach for Risks from Ingestion Exposure .....	<a href="#">8-2</a>
	8.3.1 Basic Equations .....	<a href="#">8-2</a>
	8.3.2 Exposure Areas .....	<a href="#">8-3</a>
	8.3.3 Wildlife Exposure Factors .....	<a href="#">8-5</a>
	8.3.4 Wildlife TRVs and Relative Bioavailability Factors .....	<a href="#">8-5</a>
	8.3.5 Predicted HQ and HI Values for Ingestion Exposures .....	<a href="#">8-7</a>
8.4	Direct Observations on Wildlife Species at the Site .....	<a href="#">8-8</a>
	8.4.1 Tissue Burdens in On-Site Receptors Compared to Reference .....	<a href="#">8-8</a>
	8.4.2 Small Mammal Organ Weight and Histopathology .....	<a href="#">8-10</a>
	8.4.3 Population Studies .....	<a href="#">8-11</a>
9.0	ASSESSMENT OF AMPHIBIAN COMMUNITY VIABILITY .....	<a href="#">9-1</a>
9.1	Amphibian Toxicity Benchmarks .....	<a href="#">9-1</a>
9.2	Comparison to Surface Water Concentration Values .....	<a href="#">9-1</a>
9.3	Comparison to Seep Water Concentration Values .....	<a href="#">9-2</a>
9.4	Risk of Toxicity to Amphibians from Sediment .....	<a href="#">9-2</a>
10.0	UNCERTAINTIES .....	<a href="#">10-1</a>
10.1	Uncertainties in Problem Formulation .....	<a href="#">10-1</a>
	10.1.1 Selection of Receptors .....	<a href="#">10-1</a>
	10.1.2 Selection of Exposure Pathways .....	<a href="#">10-1</a>
10.2	Uncertainties in Exposure Assessment .....	<a href="#">10-3</a>
	10.2.1 Qualitative COPCs .....	<a href="#">10-3</a>
	10.2.2 Environmental Concentrations .....	<a href="#">10-3</a>
	10.2.3 Wildlife Exposure Factors .....	<a href="#">10-4</a>
	10.2.4 Uncertainty in Absorption From Ingested Doses .....	<a href="#">10-5</a>
10.3	Uncertainties in Effects Assessment .....	<a href="#">10-5</a>
10.4	Uncertainties in Risk Characterization .....	<a href="#">10-6</a>
10.5	Summary of Uncertainties .....	<a href="#">10-6</a>
11.0	WEIGHT OF EVIDENCE EVALUATION .....	<a href="#">11-1</a>
11.1	Stream Viability and Function .....	<a href="#">11-3</a>
11.2	Riparian Floodplain Function and Viability .....	<a href="#">11-4</a>
11.3	Viability of Terrestrial Wildlife .....	<a href="#">11-5</a>
11.4	Viability of the Amphibian Community .....	<a href="#">11-5</a>
11.5	Summary .....	<a href="#">11-6</a>
12.0	REFERENCES .....	<a href="#">12-1</a>

## LIST OF FIGURES

Figure 1-1	Location of Whitewood Creek
Figure 1-2	Eight-Step Process for Ecological Risk Assessment at Superfund Sites
Figure 2-1	Homestake Open Pit
Figure 2-2	Gold Run Creek
Figure 2-3	Schematic Representation of the Geology and Water-Circulation Pathways in the Whitewood Creek Valley
Figure 2-4	Tailing Deposits along Whitewood Creek
Figure 2-5	Photographs of Whitewood Creek
Figure 3-1	Ecological Site Conceptual Model
Figure 3-2	COPC Selection Procedure
Figure 4-1	Sampling Stations Map
Figure 4-2	Location of Seeps Along Whitewood Creek
Figure 4-3	Location of Seep Samples Collected for Toxicity Testing with the Fathead Minnow
Figure 6-1	Surface Water HQs for Aquatic Receptors Based on National AWQC Values
Figure 6-2	Comparison of WAD Cyanide Concentrations with Acute and Chronic AWQC Toxicity Values for Fish and Benthic Invertebrates
Figure 6-3	Surface Water HQs for Aquatic Receptors Based on Site-Specific Standards
Figure 6-4	Relationship Between the Mean PEC Quotient and the Incident of Toxicity in Freshwater Sediments
Figure 6-5	Summary of Sediment HQs for Benthic Macroinvertebrates
Figure 6-6	Summary of Porewater HQs for Benthic Macroinvertebrates
Figure 6-7	Fish Density and Biomass in Whitewood Creek
Figure 6-8	Flowchart of Biomass Approach for Rapid Bioassessment Protocol III
Figure 6-9	Biological Condition of BMI Communities Compared to Expected Values Based on Habitat
Figure 6-10	Number of BMI Taxa per Location versus Embeddedness Score
Figure 6-11	Average Number of BMI Organisms per Sample versus Embeddedness Score
Figure 6-12	EPT Index per Location versus Embeddedness Score
Figure 7-1	Calculation of HQs for Direct Contact of Plants with Soil
Figure 7-2	Calculation of HQs for Direct Contact of Soil Invertebrates with Soil
Figure 8-1	Wildlife Exposure Reach Map
Figure 8-2	Summary of Small Mammal Tissue Concentrations by Location - Arsenic
Figure 8-3	Summary of Small Mammal Organ Weight Ratios by Location
Figure 9-1	Comparison of Dissolved COPC Concentrations in Surface Water with Acute TRVs for Amphibians
Figure 9-2	Comparison of Total COPC Concentrations in Seep Water with Acute TRVs for Amphibians

## LIST OF TABLES

Table 2-1	Timeline of Events and Reports
Table 2-2	Fish Species Observed in Whitewood Creek and the Belle Fourche River
Table 2-3	Amphibian and Reptile Species Observed within the Whitewood Creek Site Area
Table 2-4	Avian Species Observed within the Whitewood Creek Site Area
Table 2-5	Mammalian Species Observed within the Whitewood Creek Site Area
Table 2-6	Threatened or Endangered Vertebrate Wildlife Species that Potentially Inhabit the Whitewood Creek Site Area
Table 3-1	Summary of the Results of the SERA
Table 3-2	Summary of the Data Gaps Identified in the SERA
Table 3-3	Summary of COPCs Selected for Quantitative Analysis
Table 3-4	Assessment Endpoints and Associated Hypotheses and Measurement Endpoints
Table 4-1.	Summary of Data Collected in the March 1999 ERT Aquatic Field Investigation
Table 4-2.	Summary of Data Collected in the ERT Terrestrial Field Investigation
Table 5-1	Summary of Data Used in the Risk Assessment
Table 6-1	Ambient Water Quality Criteria (AWQC) Values and Parameters
Table 6-2	Summary of Sediment Data Used in the ERA
Table 6-3	Reliability of Individual Consensus-Based Sediment Quality Guidelines
Table 6-4	Sediment Toxicity Benchmarks for Benthic Invertebrates
Table 6-5	Results of the Analysis for SEM/AVS in Sediments
Table 6-6	Fish Hazard Quotients (HQs) for the Ingestion of Benthic Invertebrates
Table 6-7	Fish Hazard Quotients (HQs) for the Incidental Ingestion of Sediments
Table 6-8	Summary of MATCs for Fish Tissue
Table 6-9	Fish Hazard Quotients Based on Tissue Burdens
Table 6-10	Results of Sediment Toxicity Tests ( <i>Hyaella azteca</i> )
Table 6-11	Correlation of COPCs with <i>Hyaella azteca</i> Toxicity
Table 6-12	Seep Water Concentrations and Hazard Quotients
Table 6-13	Upstream-Downstream Comparison Near Seeps
Table 6-14	Mean Survival of Fathead Minnow Exposed to Seep Water
Table 6-15	Summary of Aquatic Community Studies
Table 6-16	Summary of Benthic Matrices for Whitewood Creek, Belle Fourche River, and Spearfish Creek
Table 6-17	Correlation of COPC Concentrations with Benthic Macroinvertebrate Metrics
Table 6-18	Summary of Bioassessment Protocol Habitat Scores for Whitewood Creek, Belle Fourche River, and Spearfish Creek
Table 6-19	Comparison of BMI Communities in Whitewood Creek Below Gold Run with Whitewood Creek Reference Location
Table 7-1	Surface Soil Data Used in the ERA
Table 7-2	Phytotoxicity Benchmarks for Terrestrial Vegetation
Table 7-3	Seep Water Hazards Quotients (HQs) for Terrestrial Plants
Table 7-4	Toxicity Benchmarks for Soil Invertebrates
Table 7-5	Results of Soil Toxicity Tests with the Turnip Seed
Table 7-6	Results of Soil Toxicity Tests with Ryegrass

## **LIST OF TABLES (CONT.)**

Table 7-7	Correlation Between COPCs in Soil and Toxicity to Ryegrass
Table 7-8	Results of Soil Toxicity Tests with the Earthworm
Table 7-9	Correlation Between COPCs in Soil and Toxicity to Earthworms
Table 7-10	Results of the Terrestrial Habitat Evaluation
Table 7-11	Results of Soil Microbial Community Analyses
Table 8-1	Summary of Receptors and Exposure Pathways
Table 8-2	Summary of Exposure Point Concentrations for Wildlife
Table 8-3	Exposure Factors for Representative Wildlife Species
Table 8-4	Dietary Fractions for Representative Wildlife Species
Table 8-5	Uncertainty Factors Used in Deriving Terrestrial TRVs
Table 8-6	Summary of Toxicity Reference Values (TRVs) for Wildlife Receptors
Table 8-7	Summary of Hazard Indices for Wildlife Receptors
Table 8-8	Summary of Results of Small Mammal Histological Evaluations
Table 9-1	Amphibian Toxicity Benchmarks
Table 10-1	Summary of Qualitative COPCs
Table 11-1	Assessment of Testable Hypotheses for Stream Function and Viability
Table 11-2	Weight of Evidence Evaluation for Stream Function and Viability
Table 11-3	Assessment of Testable Hypotheses for Riparian Floodplain Function and Viability
Table 11-4	Weight of Evidence Evaluation for Riparian Floodplain Function and Viability
Table 11-5	Assessment of Testable Hypotheses for Wildlife Viability
Table 11-6	Weight of Evidence Evaluation for Wildlife Viability
Table 11-7	Assessment of Testable Hypotheses for Amphibian Viability
Table 11-8	Weight of Evidence Evaluation for Amphibian Viability

## LIST OF APPENDICES

Appendix A	Summaries of Key Investigations, Studies, and Regulatory Documents
Appendix B	Wildlife Representative Species Profiles and Exposure Factors
Appendix C	Summary of the Selection of Chemicals of Potential Concern (COPCs)
Appendix D	Analytical Results ( <i>electronic only</i> )
Appendix E	Detailed Risk Calculations for Aquatic Receptors from Direct Contact with Surface Water - Based on National Ambient Water Quality Criteria (AWQC)
Appendix F	Detailed Risk Calculations for Aquatic Receptors from Direct Contact with Surface Water - Based on Site-Specific Toxicity Standards
Appendix G	Detailed Risk Calculations for Benthic Macroinvertebrates from Direct Contact with Sediment
Appendix H	Detailed Risk Calculations for Terrestrial Plants from Direct Contact with Surface Soil
Appendix I	Detailed Risk Calculations for Soil Organisms from Direct Contact with Surface Soil
Appendix J	Summary of Bioaccumulation from Soil and Sediment into Biota Tissue
Appendix K	Wildlife Toxicity Reference Value Derivation
Appendix L	Detailed Risk Calculations for Wildlife Receptors of Concern
Appendix M	Summary of Small Mammal Tissue Concentrations

## LIST OF ACRONYMS AND ABBREVIATIONS

AVS	Acid Volatile Sulfide
AWQC	Ambient Water Quality Criteria
BW	Body Weight
CCME	Canadian Council of Ministries of the Environment
CERCLA	Comprehensive, Environmental Response, Compensation and Liability Act
COPC	Chemical of Potential Concern
DQO	Data Quality Objective
DW	Dry Weight
EA	Endangerment Assessment
EC20	Effective Concentration for 20% of organisms tested
EC50	Effective Concentration for 50% of organisms tested
ED50	Effective Dose for 50% of the Organisms
EMAP	Environmental Monitoring and Assessment Program
EPT	Ephemeroptera, Plecoptera and Trichoptera
ERA	Ecological Risk Assessment
ERAG	Ecological Risk Assessment Guidance for Superfund
ERL	Effects Range Low
ERM	Effects Range Median
ERT	Environmental Response Team
FS	Feasibility Study
HI	Hazard Index
HMC	Homestake Mining Corporation
HQ	Hazard Quotient
ISSI	Information Systems Solutions International
LC50	Lethal Concentration for 50% of organisms tested
LOAEL	Lowest Observed Adverse Effect Level
LOEC	Lowest Observed Effect Concentration
MATC	Maximum Allowable Tissue Concentration
NEC	No Effect Concentration
NOAEL	No Observed Adverse Effect Level
NOAA	National Oceanic and Atmospheric Administration
NPL	National Priorities List
ORNL	Oak Ridge National Laboratory
PEL	Probable Effect Level
QAWP	Quality Assurance Work Plan
RBA	Relative Bioavailability
RBP	Rapid Bioassessment Protocols
RI	Remedial Investigations
RI/FS	Remedial Investigation/Feasibility Study

## **LIST OF ACRONYMS AND ABBREVIATIONS (CONT.)**

RIVM	Rijksinstituut Voor Volksgezondheid En Milieu (National Institute of Public Health and the Environment)
ROD	Record of Decision
SCM	Site Conceptual Model
SDDENR	South Dakota Department of Environment and Natural Resources
SDGFP	South Dakota Department of Game Fish and Parks
SDWNR	South Dakota Department of Water and Natural Resources
SEC	Sediment Effect Concentration
SEM	Simultaneously Extracted Metals
SERA	Screening Ecological Risk Assessment
SET	Severe Effects Threshold
TAL	Target Analyte List
TEL	Threshold Effect Level
TRV	Toxicity Reference Value
UF	Uncertainty Factor
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WQM	Water Quality Monitoring
WW	Wet Weight
WWC	Whitewood Creek

# **EXECUTIVE SUMMARY**

## **1.0 INTRODUCTION**

### **Purpose**

This document is a baseline ecological risk assessment (ERA) for the former Whitewood Creek Superfund Site, located near Whitewood, South Dakota (Figure ES-1). This ERA was completed as part of the five-year review process to help determine whether the remedial action specified for this site (USEPA, 1990a) is protective of the environment.

### **Approach**

This ERA was completed in accordance with current United States Environmental Protection Agency (USEPA) guidance for performing ecological risk assessments (USEPA, 1992, 1997a, 1998). The ecological risk assessment process was initiated by performing a screening-level ecological risk assessment (SERA) (ISSI, 1998). The SERA indicated that risks to environmental receptors may exist at the site, and identified data needed for the completion of a more detailed evaluation.

In accord with the findings of the SERA, several data collection efforts were conducted to support a more detailed and thorough evaluation of ecological impacts at the site. The current baseline ERA report utilizes the new data along with the historical data to provide an updated and refined ecological risk evaluation for the site.

## **2.0 SITE CHARACTERIZATION**

### **Site Description**

A large gold mine operated by Homestake Mining Company (HMC) is located in Lead, South Dakota. During the period between 1870 and 1977, tailings and other mining wastes generated during the operation of the mine were released into Gold Run Creek, which drains directly into

Whitewood Creek between the towns of Lead and Deadwood. Whitewood Creek flows northward, discharging into the Belle Fourche River (Figure ES-1).

### **Basis for Concern**

The principal reason for concern at the site is the presence of tailings materials along Whitewood Creek and the Belle Fourche River. It is estimated that approximately 25 to 37 million tons of tailings were deposited in the floodplain. Tailings generally contain elevated levels of a number of metals, and these may potentially be hazardous to both aquatic and terrestrial receptors. In addition to tailings, water released from the mine site (both historically and at present) into Gold Run Creek may contain elevated levels of metals and other chemicals used in the mining process (e.g., cyanide). This ecological risk assessment focuses on risks to the environment along Whitewood Creek from Gold Run Creek to the Belle Fourche River, and downstream along the Belle Fourche River below Whitewood Creek.

### **Environmental Setting**

#### *Vegetative Cover*

Vegetative communities along Whitewood Creek change between the upper and lower portions of the stream. In the upper reaches the topography is steeper and more broken with floodplain width being more restricted. Woodland composition is dominated by bur oak with cottonwood and ponderosa pine occurring in relatively small quantities. In the lower reaches, the reduced gradients and lower elevations are associated with an increase in the occurrence of American elm, box elder, green ash, and a decrease in bur oak. Cottonwoods and willow attain greater frequency as the transition occurs from the broken terrain of the foothills to the relatively level terrain of the plains.

#### *Aquatic Ecology*

The upper third of Whitewood Creek is cold and fast-flowing, with a fish community dominated by cold-water species. The middle third of the creek is a transitional area where the stream gradient becomes shallower and the water becomes warmer and has more pools and riffles. The lower third of the creek runs onto a low-gradient landscape before emptying into the Belle Fourche River, and is dominated by warm-water fish species.

A total of 15 different fish species have been reported to occur in Whitewood Creek, with the most common being brown trout, brook trout, white sucker, mountain sucker, and several species of minnows (longnose dace, creek chub, flathead chub, sand shiner, and fathead minnow). Age class analysis of brown trout populations suggest this species is reproducing naturally. The benthic community in Whitewood Creek is generally characterized by about 40-70 different taxa of invertebrates. These are mainly aquatic insects (including representatives of each of five different feeding groups), along with some worms, clams, and snails. The periphyton community is usually characterized by about 30-50 species of algae. These are predominately diatoms, but some filamentous algae are also present.

### *Terrestrial Ecology*

The riparian corridor along Whitewood Creek and the Belle Fourche River is utilized by a wide variety of terrestrial species, including 7 species of amphibians and reptiles (see Table 2-3), 126 species of birds (see Table 2-4), and 22 species of mammals (see Table 2-5). There are 12 threatened or endangered vertebrate wildlife species that could potentially occur in the area of the site, but only one of these (the bald eagle) has been documented in the site.

## **3.0 PROBLEM FORMULATION**

Figure ES-2 presents the conceptual model for the baseline ecological risk assessment. As shown, tailings deposits, including bed sediments and overbank and floodplain deposits along Whitewood Creek and the Belle Fourche River, may release chemical constituents to the overlying surface water and interstitial pore water. Tailings deposited in overbank and floodplain soils may leach chemicals to groundwater which could be transported to surface waters and seeps. Overbank tailings deposits may also collapse and erode into the stream, resulting in the on-going release of chemical-containing particles into surface water and sediments. Chemicals that are present in surface waters, sediments, and soil may be accumulated within the aquatic and terrestrial food chains, leading to exposure of higher trophic level predators. In addition to historical tailings releases, in recent years several accidental slurry releases have also occurred. These releases resulted in the discharge of heavy metals and cyanide directly into Gold Run Creek which drains into Whitewood Creek.

Ecological receptors that may be exposed to chemical contaminants include aquatic receptors (fish, benthic macroinvertebrates and aquatic plants), amphibians (aquatic life stage), terrestrial

receptors (terrestrial plants, soil and terrestrial invertebrates), and wildlife receptors (birds and mammals). Exposure pathways of chief concern are summarized below:

Ecosystem	Receptor	Exposure Pathways of Primary Concern
Aquatic	All	Direct contact with chemicals in water
	Fish	Ingestion of food web items
	Benthic organisms	Contact with sediment and porewater
Semi-aquatic	Amphibians	Direct contact with surface and seep water
Riparian zone soils	Plants, Soil invertebrates	Direct contact with chemicals in soil or shallow seep water
Terrestrial	Wildlife receptors	Ingestion of surface and seep water Ingestion of soil or sediment Ingestion of food web items

### **Selection of Indicator Species**

It is not feasible to evaluate exposures and risks for each species potentially present within the site. For this reason, specific wildlife species are identified as surrogates (representative species) for the purpose of estimation of exposure and risk in the ERA. The surrogate species are wildlife species present within the Site area that are representative of other species with similar dietary preferences and feeding guilds. Selection criteria for wildlife surrogate species include trophic level, feeding habits, and the availability of life history information. The species identified as surrogate species at this site include:

- Masked shrew (mammalian insectivore)
- American robin (avian omnivore)
- Deer mouse (mammalian omnivore)
- Meadow Vole (mammalian herbivore)
- Cliff swallow (avian insectivore)
- Belted kingfisher (avian piscivore)
- Mink (mammalian piscivore)
- Red fox (mammalian carnivore)
- American kestrel (avian carnivore)
- Great Horned Owl (avian carnivore)
- American Dipper (avian insectivore)

## **Selection of Chemicals of Potential Concern**

Chemicals of Potential Concern (COPCs) are chemicals which exist in the environment at concentrations that might be of potential concern to ecological receptors, and which are derived, at least in part, from site-related sources. The procedure used to select COPCs for this ERA is presented schematically in Figure ES-3. In brief, if there was no toxicity reference value (TRV) to evaluate the potential effects of the chemical, the chemical was assigned to the "Qualitative COPC" category (Type 1). Chemicals that have an appropriate TRV but were detected in less than 5% of the samples from a medium (surface water, sediment, soil) were usually excluded from further consideration, since chemicals that are rarely detected at a site are not likely to be site-related. However, if the detection limit for a chemical was too high to expect detection of the chemical if it were present at a level of concern, the chemical was assigned to the "Qualitative COPC" category (Type 2). If a TRV was available for a chemical and the maximum detected value of the chemical (from anywhere on the site) was less than the TRV, it was concluded that the chemical does not occur at a level of potential concern, and it was not evaluated as a COPC. If the maximum detected value did exceed the TRV, then the chemical was evaluated quantitatively. It should be noted that this selection procedure is intended to be conservative; that is, the selection procedure is intended to eliminate only those chemicals that are clearly not of potential ecological concern, and to carry forward those chemicals that might be of concern. The results of the COPC selection procedure are detailed in Appendix C and are summarized in Table ES-1.

## **Assessment Endpoints, Measurement Endpoints, and Testable Hypotheses**

Assessment endpoints are explicit statements of the characteristics of the ecological system that are to be protected. Measurement endpoints represent quantifiable ecological characteristics that can be measured, interpreted, and related to the valued ecological components chosen as the assessment endpoints. At this site, four main assessment endpoints were established:

- Stream Viability and Function
- Riparian Floodplain Function and Viability
- Viability of Wildlife
- Viability of Amphibian Community

Table ES-2 summarizes the testable hypotheses and measurement endpoints selected for each of these assessment endpoints.

#### **4.0 INVESTIGATIONS CONDUCTED SINCE THE SERA**

As noted above, the SERA identified a number of data gaps where additional information was needed to help improve the reliability and accuracy of the ecological risk assessment. In order to address these data needs, the USEPA Environmental Response Team (USEPA/ERT) and USEPA Region 8 performed aquatic and terrestrial field sampling in March and August 1999 (USEPA 2001a, 2001b). The study included 12 sampling locations along Whitewood Creek, the Belle Fourche River, and Spearfish Creek (used as a reference area). Data collected included the following:

##### Aquatic Investigation

- Concentration levels of COPCs in surface water, sediment, groundwater and seep water
- Concentrations of COPCs in the tissues of benthic macroinvertebrates and fish
- Density and diversity of benthic macroinvertebrates in sediment
- Laboratory-based toxicity of sediment to an invertebrates species (*Hyalella azteca*)
- Acid volatile sulfide and simultaneously extractable metals in sediment
- Habitat suitability data

##### Terrestrial Investigation

- Concentration levels of COPCs in soil
- Concentrations of COPCs in the tissues of small mammals
- Concentrations of COPCs in plant tissues
- Laboratory-based toxicity of soil to plants and earthworms
- Examination of small mammals for abnormal size or histopathology
- Qualitative survey of vascular plant species abundance
- Characterization of soil microbial community

In addition to the studies performed by USEPA, a number of other studies were performed that provided new information on the density and diversity of aquatic species (Knudsen, 2001a, 2001b; Chadwick, 2001) and terrestrial species (Custer, 1997) in the study area. All of these data were evaluated for use in the baseline ecological risk assessment, as described below.

## 5.0 DATA EVALUATION AND USABILITY

All previous and current investigations and site monitoring of the Whitewood Creek Site were reviewed for the availability of reliable and relevant analytical and biological data that could be used in the baseline ERA. Because the purpose of the risk assessment is to evaluate potential hazards from current site conditions, only data from 1990 and later were employed.

Studies that were selected for use in the ERA are summarized in Table ES-3. As seen, there are reliable COPC concentration data for all of the abiotic media of potential concern (surface water, sediment, soil, and seep water), as well as a number of biological media (fish, benthic invertebrates, plants, birds, small mammals, and soil invertebrates). In addition, there are a number of site-specific toxicity studies and population surveys that contribute valuable information. All of these data were considered in the risk assessment.

## 6.0 ASSESSMENT OF STREAM VIABILITY AND FUNCTION

### Basic Approach

Several different approaches were used to assess stream viability and function in the study area, including the following:

#### Comparison of COPC Concentrations in Site Media to Toxicity Benchmarks

One way to characterize the potential risks to aquatic receptors from exposure to COPCs in surface water or sediment is the Hazard Quotient (HQ) approach. The HQ is defined as the ratio of the exposure point concentration to an appropriate toxicity benchmark:

$$HQ = \frac{\text{Concentration}}{\text{Benchmark}}$$

If the HQ is less than or equal to one (1E+00), it is believed that no unacceptable effects will occur in the exposed aquatic population. If the value of HQ exceeds 1E+00, then unacceptable effects may occur, with the likelihood and/or severity of effects tending to increase as the value of the HQ becomes larger. This approach may be applied to both abiotic media (surface water, sediment, porewater, seepwater) and to biotic samples (tissues of fish and benthic organisms).

### Site-Specific Toxicity Tests

Another way to assess the risks from contamination in the aquatic ecosystem is to perform direct toxicity tests (usually in the laboratory) by exposing a test organism directly to a site medium (e.g., surface water, sediment, porewater, seep water). Such tests provide direct information on the hazard posed by the site media to the test organisms.

### Population Surveys

A third way to evaluate mining-related impacts on the aquatic community is to perform direct observations on the density and diversity of aquatic receptors in Whitewood Creek and to compare those observations with what would be expected in the absence of mining-related impacts. This is usually done by using data from an upstream reach or from a similar (but unimpacted) stream in a nearby location as a reference site.

## **Results**

### HQ Values for Aquatic Receptors from Direct Contact with Surface Water

- Based on national Ambient Water Quality Criteria (AWQC) values, acute HQs for dissolved aluminum, copper, lead, selenium, and silver in surface water are below a level of concern at all sampling locations.
- Chronic HQs for dissolved copper, lead, and selenium in surface water are below a level of concern for a majority of samples at most Whitewood Creek stations downstream of Gold Run Creek. However, some HQ values greater than 1E+00 do occur, suggesting that these chemicals may contribute an intermittent low-level stress on aquatic receptors.
- Acute and chronic HQs for weak acid dissociable (WAD) cyanide are largely above a level of concern at most stations on Whitewood Creek, and do not drop below a level of concern until many miles downstream of Gold Run Creek. However, the TRV for cyanide is based on free cyanide, and HQ values based on WAD cyanide may overestimate hazard.
- HQs based on site-specific surface water standards for copper, lead, silver, and cyanide (as WAD cyanide) are all below a level of concern at nearly all locations. These site-specific standards are based on the protection of stockable brown trout for a period of up to 90

days. These results indicate that toxicity from surface water to stockable trout species in Whitewood Creek is unlikely to occur. It is important to note, however, that these site-specific standards are not intended to be protective of younger and more sensitive life stages of trout and other aquatic receptors, and that compliance with the site-specific standards is not direct evidence that there are no risks to the aquatic community.

#### HQ Values for Benthic Organisms from Direct Contact with Sediments

- Based on published sediment quality guidelines, predicted HQ values for sediment are generally below a level of concern for cadmium, manganese, nickel, and zinc.
- HQ values for copper, lead, and mercury exceed a level of concern based on the lowest TRV but are of minimal concern based on the highest TRV. Based on these comparisons, sediment toxicity from these chemicals is considered possible, but not certain.
- HQ values for arsenic are substantially above 1E+00 at all non-reference segments of Whitewood Creek and the Belle Fourche River, based on both the lower and upper toxicity benchmarks. Based on this, arsenic is identified as a potential source of sediment toxicity.
- At most locations on Whitewood Creek, sediment contains an excess of sulfide over metals concentration, indicating that toxicity is not expected. Small excesses (less than 1  $\mu\text{mol/g}$ ) of metals over sulfide occurred at some stations, but the excess is sufficiently small such that other binding agents (e.g., organic carbon) may attenuate exposures from any metals that may leach into porewater.

#### Risks to Fish from Ingestion of Benthic Macroinvertebrates

- Based on screening-level oral TRV values, HQ values do not exceed a value of 1E+00 for ingestion of cadmium, copper, lead, or zinc in prey items by fish, but do occasionally exceed a value of 1E+00 for arsenic. These results suggest that ingestion of arsenic in food web items might be of concern to fish. However, if any effects occur from dietary exposure of fish, the results are likely to be minimal.

- HQ values to fish from incidental ingestion of sediment while feeding do not exceed a value of 1E+00 for any sediment sample at any station. This indicates that direct ingestion of sediment by fish is not likely to be of concern.

#### HQ Values Based on Fish Tissue Data

- HQ values for fish based on COPCs measured in fish tissue are consistently above 1E+00 for mercury and zinc, but this occurs at the reference locations as well as the site stations, suggesting the tissue-based TRVs for these chemicals may be somewhat too low.
- There are two stations where the HQ based on arsenic is greater than 1E+00, both in the upper reaches of Whitewood Creek. This suggests that arsenic might be of concern to some individual fish but probably not all fish (the average HQ for arsenic for all fish excluding reference locations is 6E-01). However, the data are too limited and the values too variable to draw a firm conclusion.

#### Assessment of Seep Water Toxicity

- Some metals are up to an order of magnitude more concentrated in seep water than in Whitewood Creek, and influx of seep water often leads to an observable increase in metals concentration in the surface water downstream of the seep.
- Concentrations of arsenic in undiluted seep water exceed the acute and/or chronic AWQC for arsenic at several different seeps. However, concentrations of arsenic in the stream downstream of the seeps do not exceed a level of concern.
- The site-specific seep water samples and samples from the stream downstream of the seeps are not acutely toxic to the fathead minnow after 96 hours of exposure in laboratory testing (USGS, 2000).
- Based on these observations, seep water is considered to be a source of contamination in Whitewood Creek, but is not likely to be a source of significant toxicity to aquatic receptors.

### Direct Sediment Toxicity Testing

- Sediment toxicity tests using *Hyalella azteca* suggest that arsenic, cadmium, and/or mercury levels in sediment or porewater might increase the risk of acute mortality in exposed benthic organisms, but this conclusion is limited by the potential confounding effects of elevated levels of ammonia in the porewater. In addition, the porewater collected during laboratory-based sediment toxicity testing may not accurately reflect metal concentrations in pore water *in situ*. Thus, firm conclusions are not possible from the available sediment toxicity tests.

### Aquatic Population Studies

- Studies of fish, benthic macroinvertebrate, and periphyton communities in Whitewood Creek indicate that populations are relatively diverse and abundant, although quantitative comparisons with reference areas are limited.

## **7.0 ASSESSMENT OF RIPARIAN FLOODPLAIN FUNCTION AND VIABILITY**

### **Basic Approach**

The health of the riparian floodplain was assessed by focusing on the status of the terrestrial rooted vascular plant community and on soil invertebrates. As above, risks were evaluated using a variety of methods, including calculation of HQ values, direct toxicity testing, and observation of population status.

### **Results**

#### Soil Concentrations Compared to Phytotoxicity Benchmarks

- For antimony, barium, copper, lead, mercury, molybdenum, nickel, silver, thallium, and zinc, most or all calculated HQs are below a level of concern, indicating phytotoxicity from these metals in floodplain soils is unlikely.
- HQs for aluminum, boron, chromium, and vanadium are greater than 1E+00 at all stations, including each of the reference locations. This indicates that the selected phytotoxicity

benchmark values for these chemicals are probably not appropriate for soil conditions in the Whitewood Creek site and may over-predict risks.

- For arsenic, HQ values are above a level of concern at all site locations, but are below a level of concern at all reference stations. This suggests that arsenic in site soils could be a source of phytotoxicity.
- Manganese HQs tend to follow a pattern that is qualitatively similar to arsenic, with most Whitewood Creek soils at or above a level of concern, while reference areas are below a level of concern. However, the magnitude of the exceedences for manganese are much smaller than for arsenic, indicating that if manganese is of concern, the severity of the effect is likely to be minor.

#### Seep Water Concentrations Compared to Phytotoxicity Benchmarks

- All HQ values for exposure of plants to seep water are below 1E+00 for all COPCs except arsenic. Arsenic concentrations in seep water exceed the screening benchmark at all stations except the reference location. These results indicate that phytotoxicity from root exposure to arsenic in seep water could be occurring. However, confidence in this conclusion is limited, for two reasons. First, seep water may not be indicative of soil water in the root zone of riparian area plants. Second, there is low confidence in the screening benchmark for arsenic due to a limited number of literature values, and because the value is not based on site-specific studies.

#### Soil Concentrations Compared to Benchmarks for Soil Organisms

- HQ values for exposure of soil organisms to COPCs in soil are all at or below a level of concern for barium, boron, copper, lead, mercury, molybdenum, nickel, silver, vanadium, and zinc. This indicates that these metals are not likely to be of concern to soil organisms in floodplain soils.
- HQs for aluminum, iron, and manganese are greater than 1E+00 at all locations, but the values at reference locations are generally similar to the site locations. A generally similar pattern is observed for chromium, although the HQ exceedences are lower. This indicates that the selected soil organism benchmark for these chemicals may over predict risks and may not reflect soil conditions in the Whitewood Creek site.

- Arsenic HQs are above a level of concern at all site locations, and are below a level of concern at all reference locations. This indicates that arsenic in floodplain soils at the site may be toxic to soil invertebrates.

#### Site-Specific Soil Toxicity Tests with Plants

- Toxicity tests based on turnip seeds were not considered to be reliable due to a probable effect of soil pH adjustment on plant growth and survival.
- Growth responses for rye grass seeds grown in soils from three site locations (WWC-05, WWC-06, and WWC-08) were not significantly lower than for seeds grown in soil from WWC reference area.
- Growth responses for rye grass seeds grown in soils from WWC-05, WWC-06, and WWC-08 were not significantly lower than for seeds grown in laboratory control soil, except for shoot length and biomass at WWC-08.
- All of the growth responses for seeds grown in soils from WWC-05, WWC-06, or WWC-08 were significantly lower ( $p < 0.01$ ) than for seeds grown in soil from a reference location on Spearfish Creek (SPC-R-12), except for root biomass at WWC-05. The basis for this difference is not known.
- With one exception, no association of potential concern was detected between the concentration of any COPC and any of the measures of phytotoxicity. Because this analysis tested 125 different relationships, the occurrence of only one apparently significant relationship could be due to chance rather than an authentic chemical-related effect.

#### Site-Specific Soil Toxicity Tests with Earthworms

- None of the earthworms survived in soil from station WWC-05. However, survival of earthworms exposed to soils from four other stations (WWC-06, WWC-07, WWC-08, and WWC-09) was not statistically different from any of the control soils.

- Mean length and mean weight were not significantly different in worms exposed to Whitewood Creek soils compared to laboratory control soil or Whitewood Creek reference soil. Compared to Spearfish Creek soil, there was a decrease in length for worms exposed for 14 days (but not 28 days) to soil from WWC-07, and an increase in weight loss for worms from WWC-08 and WWC-09.
- Correlation analysis of soil concentrations of each COPC with earthworm toxicity revealed no consistent pattern across time or location. This suggests that any apparent associations may be random rather than authentic dose-response effects.

#### Comparison of the Vascular Plant Community to Reference

- Studies are available that provide information on the nature of plant communities within and near the site. However, none of these studies provide data that correlate plant community density or diversity to concentrations of COPCs or other soil attributes (pH, organic carbon content, etc.), and none provide a quantitative comparison of density and diversity at site locations to appropriate reference areas. Thus, these studies do not allow an evaluation of whether COPCs in riparian soils are causing adverse effects on the vascular plant community.

#### Comparison of Soil Functions to Reference

- USEPA ERT (USEPA 2001b) conducted a study to evaluate the ecological integrity of the soil ecosystem, including total and active biomass for bacteria and fungi, abundances of protozoans (flagellates, amoebae, and ciliates), nematode abundances, and percent colonization of roots by mycorrhizal fungi. However, due to a lack of understanding of what range of measures for these various measurement endpoints is associated with normal and impaired soil functioning, these data were not found to be applicable to a quantitative risk evaluation for riparian floodplain soil integrity.

## **8.0 ASSESSMENT OF WILDLIFE VIABILITY**

### **Basic Approach**

In order to evaluate risks to terrestrial wildlife receptors, the riparian area along Whitewood Creek and the Belle Fourche River was divided into a number of zones, as follows:

Exposure Zone	Description
WWC - Reach A	Whitewood Creek upstream of Gold Run Creek (reference area for WWC - Reach B)
WWC - Reach B	Whitewood Creek downstream of Gold Run Creek to the Crook City bridge
WWC - Reach C	Whitewood Creek downstream of the Crook City bridge to Crow Creek confluence
WWC - Reach D	Whitewood Creek from Crow Creek confluence to Belle Fourche River
BFR - Reach A	Belle Fourche River upstream of Whitewood Creek (reference area for BFR - Reach B)
BFR - Reach B	Belle Fourche River downstream of Whitewood Creek
SPC	Spearfish Creek (reference area for WWC - Reach C & D)

Risks were evaluated on a zone-by-zone basis mainly by the HQ approach. In the case of wildlife receptors, most TRVs are based on ingested dose, so exposure to receptors was estimated by calculating the expected intake of COPCs in water, soil, sediment, and the diet. In addition, risks were also evaluated based on measured levels of COPCs in tissues of wildlife receptors, direct observations on small mammal health, and surveys of wildlife receptor density and diversity.

## Results

### Predicted Risks from Ingestion Exposures

- For the great horned owl and the American dipper, predicted Hazard Index (HI) values (the sum of the HQ values for all exposure pathways) do not exceed a level of concern (1E+00) for any COPC at any location.
- Several COPCs (including aluminum, antimony, barium, lead, manganese, molybdenum, thallium, and vanadium) are predicted to cause HI values above 1E+00 for one or more receptors, but in all cases the HI value exceeds a value of 1E+00 in one or more reference areas as well as site areas. This suggests that the TRVs and/or the relative bioavailability values for these COPCs may be too conservative, since toxicity is not expected to be

significant in reference areas. Thus, these HI values should be not be interpreted as strong evidence of potential harm.

- Arsenic is predicted to cause HI values well above 1E+00 for a majority of receptors in most site exposure zones, but not in any reference zones. These elevated HI values are due almost entirely to ingestion of soil or sediment while feeding (see Appendix L), with relatively little contribution from water or food web items. This indicates that arsenic in soil or sediment might pose a health risk to a majority of wildlife receptors, including representatives of nearly all feeding guilds.
- Ingestion of seep water is not a source of concern to any wildlife receptor.

#### Tissue Burdens in Wildlife Receptors

- Qualitative evaluation of COPC levels in the tissues of small mammals did not suggest that any chemical was more concentrated in tissues from on-site locations than for reference locations, except for arsenic. Note that this finding demonstrates that small mammals have increased exposure to arsenic, but in the absence of a tissue level of arsenic that is associated with adverse health effects, this finding alone should not be interpreted as proof that arsenic is causing an adverse effect in small mammals.
- Birds from Whitewood Creek have higher exposure to arsenic than birds from the reference area. However, in the absence of other information, this should not be considered to be evidence of an arsenic-related adverse effect.

#### Small Mammal Organ Weight and Histopathology

- There is no clear difference in relative liver weights or relative kidney weights in small mammals collected from White Creek sites compared to reference sites.
- There is a tendency for relative spleen weights to be higher in animals from Whitewood Creek sites than reference locations, but the increase in spleen weight could not be correlated with concentrations of any COPC measured in whole body tissue. The cause of this observed effect is unknown.

- There appears to be an general increase in the incidence of abnormal histopathology in the spleen, liver, and kidney from small mammals collected onsite compared to the reference areas. Two of the results (kidney abnormalities at WWC-08 and spleen abnormalities at WWC-06) are significantly different than for the reference areas, but the lack of a consistent effect across locations decreases confidence that these effects are COPC-related.

### Population Studies

- Several surveys have established that there are a large number of avian and mammalian species present in and about the site. However, simple observation of the occurrence of wildlife species in the site area is not evidence that mining-related wastes are having no effect.

## **9.0 ASSESSMENT OF AMPHIBIAN COMMUNITY VIABILITY**

### **Basic Approach**

The health of the amphibian community along Whitewood Creek was assessed by the HQ approach. No site-specific toxicity test results or population surveys were available for this class of receptor.

### **Results**

#### HQ Values Based on Surface Water Concentration Values

- Concentration values of dissolved aluminum in surface water in Whitewood Creek might occasionally reach a level of concern for the Eastern narrow-mouthed toad, but other amphibian species for which toxicity data exist are not at risk from this COPC at this site. Because the concentration of aluminum shows little spatial pattern, aluminum concentrations are probably not substantially increased by mine-related releases.
- Concentrations of dissolved copper, lead, and selenium do not exceed a level of concern based for any of the species for which toxicity data are available.

- Concentrations of dissolved silver reach or exceed a level of concern for two amphibian species (Eastern narrow-mouthed toad, common Indian toad) in the upper reaches but not in the lower reaches of Whitewood Creek.

#### HQ Values Based on Seep Water Concentration Values

- With the exception of a few data points for aluminum and one data point for lead, concentrations of COPCs in seep water are below a level of concern for all of the amphibian species for which TRVs could be located. This suggests that seep waters are not likely to be a significant source of exposure or risk to amphibians who may have direct contact with the seep water.

#### Risk of Toxicity to Amphibians from Sediment

- Toxicity data are not available to support risk evaluation risks to amphibians from direct contact with sediments. However, this exposure pathway is likely to be minor compared to direct contact with COPCs in surface water or seep water.

### **10.0 UNCERTAINTIES**

Quantitative evaluation of ecological risks is limited by uncertainty regarding a number of important data, exposure, toxicity, and risk factors. This lack of knowledge is usually circumvented by making estimates based on whatever limited data are available, or by making assumptions based on professional judgement when no reliable data are available. Because of these assumptions and estimates, the results of the risk calculations are themselves uncertain, and it is important for risk managers and the public to keep this in mind when interpreting the results of a risk assessment.

Key sources of uncertainty in this risk assessment are summarized below.

#### **Uncertainties in Problem Formulation**

##### *Selection of Receptors*

Risks to wildlife are assessed for a small subset of the species likely to be present in the Whitewood Creek Site. The representative wildlife species selected for quantitative evaluation

represent a range of taxonomic groups and life history types. An effort was made to select species representing the full range of possible exposures present in the area. These species may not, however, represent the full range of sensitivities present.

### *Selection of Exposure Pathways*

The exposure pathways selected for evaluation in the ERA are not inclusive of all potential exposure pathways for all ecological receptors. Pathways were excluded from quantitative evaluation either because they are believed to be minor, or because available data are not adequate to support a meaningful quantitative evaluation. Omission of a pathway that is minor will lead to a small underestimation of hazard, but this is not a significant source of uncertainty. Pathways that are excluded because of lack of data could result in a larger underestimation of hazard, but the degree of underestimation is not known.

## **Uncertainties in Exposure Assessment**

### *Uncertainty from Chemicals Not Evaluated*

As discussed in Section 3, any chemical that was detected in a site medium but which lacks a toxicity value was assigned to a list of Qualitative COPCs (Type 1). Likewise, chemicals that were detected infrequently (<5%), but which had detection limits that were too high to expect the chemical would be detected even if it were present at a level of concern, were assigned to the Qualitative COPC list (Type 2). The inability to quantify the hazard from these chemicals could lead to an underestimation of hazard to some ecological receptors. However, the magnitude of the underestimation is not necessarily substantial.

With respect to Type 1 qualitative COPCs, absence of a TRV for a chemical is sometimes due to the fact that toxicological concern over that chemical is low. Thus, chemicals that lack TRVs are often supposed to be relatively less hazardous than those for which TRVs exist (although there are likely exceptions to this rule). If so, risks from qualitative Type 1 COPCs at this site are likely not of substantial concern. Similarly, qualitative Type 2 COPCs are not likely to be a source of substantial concern (even if the detection limit is low), since if the chemical were site related or if it were present at a level of substantial health concern, it likely would have been detected more often. Thus, risks from qualitative Type 2 COPCs at this site are also not likely to be of substantial concern.

### *Uncertainties in Environmental Concentrations*

In the exposure assessment, the desired input parameter is the true mean concentration of a contaminant within a medium, averaged over the area where exposure occurs. Nearly all of the calculations of receptor exposure and risk begin with measurements of the COPCs in environmental media. As has been noted in preceding sections, even though there is an extensive database for each of these media, because of the size of the site and because of the substantial variability in concentration values over time and/or space, there is still uncertainty in the true concentration values at any particular site location.

At some locations, COPC concentrations in some prey (food) items (plants, soil invertebrates, terrestrial invertebrates, and small mammals) were not available, and site-specific relationships between soil and the food web item were not robust enough to allow estimation by modeling. Thus, exposure via food web intakes was not quantified at some locations. This will result in an underestimation of exposure and risk, but based on results from other locations where food web data were available, the magnitude of the error is probably small.

For aquatic and soil receptors, exposures are based on the distribution of values measured in individual samples of water, sediment, or soil. For terrestrial wildlife receptors, exposure is based on a conservative estimate of the mean (the 95% UCL or the maximum value). This approach is likely to result in an overestimate of exposure and risk to wildlife.

### *Uncertainty in Wildlife Exposure Factors*

Even if the concentrations of metals were known with accuracy in all abiotic and all biotic media (food web items), the actual intake of the COPCs by site wildlife receptors would still be uncertain because of the lack of site-specific knowledge of the actual intake rates. The food, soil, water, and sediment intake (ingestion) rates used to estimate COPC doses are derived from literature reports of intake rates by receptors at other locations. These rates may or may not serve as appropriate models for site-specific intake rates at this site. Ingestion-related exposure assumptions for wildlife are based on literature-derived information concerning average body sizes, diet compositions, consumption rates, and metabolic rates. Much of this information is derived from laboratory-reared animals and may not be representative of feral organisms. Moreover, the actual diet composition of an organism will vary daily and seasonally. In addition, some wildlife receptor-specific intake rates are estimated by extrapolation from data on a closely related species or by use of allometric scaling equations (scaling of intake rates based on body

weights). This introduces further uncertainty into the exposure and risk estimates. These uncertainties could either under- or overestimate the actual exposures of wildlife to COPCs in water, sediment, soil, and diet.

#### *Uncertainty in Absorption From Ingested Doses*

The toxicity of an ingested chemical depends on how much of the chemical is absorbed from the gastrointestinal tract into the body. However, the actual extent of metal absorption from ingested media (soil, sediment, food, and water) is usually not known. The hazard from an ingested dose is estimated by comparing the dose to an ingested dose that is believed to be safe, based on tests in a laboratory setting. Thus, if the absorption is the same in the laboratory test and the exposure in the field, then the prediction of hazard will be accurate. However, if the absorption of chemical from the site medium is different (usually lower) than in the laboratory study, then the hazard estimate will be incorrect (usually too high). In this assessment, estimates of wildlife exposure due to incidental soil and sediment ingestion conservatively assume a relative bioavailability of 100%. This assumption may overestimate contaminant doses to wildlife doses, since absorption efficiencies for most metals are lower in soil and sediment than in most laboratory studies.

#### **Uncertainties in Effects Assessment**

Toxicity information for many contaminants is often limited. Consequently, there are varying degrees of uncertainty associated with the wildlife toxicity reference values. Sources of uncertainty associated with toxicity values are listed below:

- Toxicity data are not available for all of the species of potential concern at the site. Thus, it is sometimes necessary to estimate toxicity values for a receptor by extrapolating across species. This extrapolation introduces substantial uncertainty into the toxicity value, usually by assuming that the species for which data are lacking might be more sensitive than the species for which data are available. This approach is more likely to overestimate than underestimate risk to ecological receptors.
- The literature-derived data used to identify toxicity benchmarks contain uncertainties related to the application of generic data to site-specific conditions. The toxicity benchmarks identified for the ERA are based on data from a wide range of sites and conditions, many of which may be quite different from the conditions at the Whitewood Creek Site. In some cases, site-specific factors may tend to modify (often decrease) the

toxicity of metals in surface water, sediments, and soil. For example, metals in surface water may be bound to soluble organic materials that reduce the tendency for the metal to bind to respiratory structures of fish or benthic organisms. Similarly, the presence of organic matter in soil, along with other substances, may have a significant influence on actual toxicity. Thus, risks based on literature-derived toxicity factors may sometimes overestimate risk from site media.

- Most TRV values are derived from studies of the adverse effects of a single contaminant. However, exposures to ecological receptors usually involve multiple contaminants, raising the possibility that synergistic or antagonistic interactions might occur. This sort of interaction is of particular importance with regard to metals, since it is known that the absorption and toxicity of some metals interact in complex ways. However, data are not adequate to permit any quantitative adjustment in toxicity values or risk calculations based on inter-contaminant interactions. This uncertainty may result in over- or underestimates of risk.
- In some cases, TRV data are available only for high dose exposures, and extrapolation to low doses (similar to those at the site) is a source of uncertainty. Likewise, some TRVs are based on relatively short-term exposures, and extrapolation to long-term conditions is uncertain, especially for chemicals that tend to bioaccumulate in the exposed organism.

### **Uncertainties in Risk Characterization**

The basic HQ approach used for estimating exposure and hazard to terrestrial receptors is to estimate the dose and the HQ for each COPC separately, and then to add HQs for a given chemical across all exposure pathways to derive a chemical-specific hazard index (HI). In accordance with USEPA guidance, effects from different COPCs are not added unless reliable data are available to indicate that the two (or more) chemicals act on the same target tissue by the same mode of action. At this site, HI values for each COPC were not added across different chemicals. If any of the chemicals were act by a similar mode of action, total risks could be higher than estimated.

### **Summary of Uncertainties**

Based on all of these considerations, the HQ and HI values calculated and presented in this ERA section should be viewed as having substantial uncertainty. Because of the inherent conservatism

in the derivation of most of the exposure estimates and the TRVs, these HQ and HI values should generally be viewed as being more likely to be high than low, and should be interpreted in a weight-of evidence approach based on other types of available information as well.

## **11.0 WEIGHT OF EVIDENCE EVALUATION**

As discussed above, three basic types of information are available to help assess the potential impacts of site contaminants on ecological receptors:

### *HQ and HI Values*

Because HQ values are not based on site-specific toxicity data, they do not account for site-specific factors that may either increase or decrease the toxicity of the metals compared to what is observed in the laboratory. For metals, this may include, for example, differences in the physical/chemical form of the metals and hence in the bioavailability and toxicity of the metals in site media compared to laboratory tests. In addition, estimates of exposure may be uncertain, especially for dose-based calculations. Therefore, HQ values should be interpreted as estimates rather than highly precise predictions.

### *Site-Specific Toxicity Studies*

Site-specific toxicity tests measure the response of receptors that are exposed to site media. The chief advantage of this approach is that site-specific conditions which can influence toxicity in site media are usually accounted for. A potential disadvantage is that, if toxic effects are observed to occur when test organisms are exposed to site media, it is usually not possible to specify which chemical(s) is (are) responsible for the effect. Rather, the results of the toxicity testing reflect the combined effect of the mixture of chemicals present in the site medium, including all of the metals of potential concern as well as any other toxic chemicals which might be present. In addition, it is often difficult to test the full range of environmental conditions which may occur at the site across time and space, so these studies are not always adequate to identify the boundary between exposures that are acceptable and those that are not.

### *Direct Observations of Receptor Diversity and Abundance*

A third approach for evaluating impacts of environmental contamination on ecological receptors is to make direct observations on the receptors in the field, seeking to determine whether any

receptor population has unusual numbers of individuals (either lower or higher than expected), or whether the diversity (number of different species) of a particular category of receptors (e.g., plants, benthic organisms, birds) is lower than expected. The chief advantage of this approach is that direct observation of community status does not require making the numerous assumptions and estimates needed in the HQ approach. However, there are also a number of important limitations to this approach. The most important of these is that both the abundance and diversity of an ecological population depend on many site-specific factors (habitat suitability, availability of food, predator pressure, natural population cycles, meteorological conditions, etc.), and it is often difficult to know what the expected (un-impacted) abundance and diversity of an ecological population should be in a particular area. This problem is generally approached by seeking an appropriate "reference area" (either the site itself before the impact occurred, or some similar site that has not been impacted), and comparing the observed abundance and diversity in the reference area to that for the site. However, it is sometimes quite difficult to locate reference areas that are truly a good match for all of the important habitat variables at the site, so comparisons based on this approach do not always establish firm cause-and-effect conclusions regarding the impact of environmental contamination on a receptor population.

#### *Weight of Evidence Approach*

As discussed above, each of the methods available for evaluating potential impacts of environmental pollution on ecological receptors has advantages and limitations. For this reason, conclusions based on only one method of evaluation may be misleading. Therefore, the best approach for deriving reliable conclusions is to combine the findings of all methods for which data are available, taking the relative strengths and weaknesses of each method into account. If the methods all yield similar conclusions, confidence in the conclusion is greatly increased. If different methods yield different conclusions, then a careful review must be performed to identify the likely basis of the discrepancy, and to decide which method is more likely to yield the correct conclusion.

#### *Scoring Evaluation of Observations*

Evaluation of the weight of evidence on a particular issue is a process that generally requires professional judgment. It is usually helpful to begin by summarizing all of the observations that bear on a particular issue, and then deciding how relevant and how convincing each observation is. That is, does the observation clearly imply that the COPCs have caused a particular effect (e.g., acute lethality), or are there other credible interpretations that might account for the

observation? For this ERA, the following qualitative scheme has been used to summarize the results of individual studies or lines of evidence:

Effect Score Criteria	
Score	Meaning
++	Strong evidence that a site exposure is causing an adverse effect
+	Evidence is consistent with, but not proof, that a site exposure is causing an adverse effect
0	Evidence neither supports nor refutes that a site exposure is causing an adverse effect
-	Evidence is consistent with, but not proof, that a site exposure is not causing an adverse effect
--	Strong evidence that a site exposure is not causing an adverse effect

Note that it is not appropriate to simply "average" all of the scores that bear on a particular issue, since different observations are usually not equally relevant. Rather, professional judgement must be used to weight the relative scientific merits of the different types of observations.

### **11.1 Stream Viability and Function**

Table ES-4 summarizes data from the site that bear on the assessment of stream viability and function. The observations are grouped to address testable hypotheses, and important strengths and limitations in the available data are noted. Based on a consideration of all of the information, a weight of evidence conclusion is derived regarding each hypothesis.

Table ES-5 combines data and conclusions across multiple testable hypotheses in order to reach overall conclusions regarding the potential for risk to aquatic receptors from each potential exposure medium, as well as an overall conclusion regarding stream function and viability. Key conclusions are as follows:

- Risks to aquatic receptors from most COPCs in surface water are generally below a level of concern, although some low level and intermittent stress may occur. Cyanide is not likely to be of concern to stockable size fish, but available data are not sufficient to

determine if sensitive life stages of fish or benthic macroinvertebrates may be at risk from cyanide.

- Risks to aquatic receptors from COPCs in sediment and pore water do not appear to be above a level of concern at most stations, although risks from arsenic and cadmium might be of concern in some locations.
- Seep water is a source of increased COPC concentrations in Whitewood Creek. However, the seep water has little apparent toxicity, and any exposures of aquatic receptors to seep water are minimized by dilution of the seep water in the creek.
- Exposures of aquatic receptors by ingestion of aquatic prey items and/or sediment do not appear to be of concern.
- Population surveys of fish and benthic invertebrates indicate that the communities are generally abundant and diverse, although the possibility of an effect cannot be excluded from these data.

Based on these findings, it is concluded that COPCs in the aquatic ecosystem may result in some stress to aquatic receptors, but that the level and severity of any effects are probably not large enough to cause substantial population-level impacts.

## **11.2 Riparian Floodplain Function and Viability**

Table ES-6 summarizes data from the site that bear on the assessment of riparian floodplain viability and function. The observations are grouped to address testable hypotheses, and important strengths and limitations in the available data are noted. Based on a consideration of all of the information, a weight of evidence conclusion is derived regarding each hypothesis.

Table ES-7 combines data and conclusions across multiple testable hypotheses in order to reach overall conclusions regarding each hypothesis as well as an overall conclusion regarding the riparian zone soil community function and viability. Key conclusions are as follows:

- Site soils are not generally toxic to plants or soil invertebrates.

- If plant roots are exposed to seep water, phytotoxicity from root exposure to arsenic could be occurring, but confidence in this conclusion is low.
- Terrestrial plant and microbial population data are insufficient to support a quantitative conclusion.

Based on these findings, it is concluded that the viability and function of the riparian floodplain is probably not substantially impacted by mining-related releases.

### **11.3 Viability of Terrestrial Wildlife**

Table ES-8 summarizes data from the site that bear on the viability of terrestrial wildlife at the site. The observations are grouped to address each of the testable hypotheses, and important strengths and limitations in the available data are noted. Based on a consideration of all of the information, a weight of evidence conclusion is derived regarding each hypothesis.

Table ES-9 combines data and conclusions across multiple testable hypotheses in order to reach overall conclusions regarding each hypothesis as well as an overall conclusion regarding risks to wildlife receptors. Key conclusions are as follows:

- Risks to wildlife do not appear to be of significant concern for exposures that occur from ingestion of surface water, seep water, or food items.
- Many terrestrial receptors are predicted to have elevated risk of adverse effects from ingestion of arsenic in soil or sediment.
- Site data confirm that small mammals have increased exposure to arsenic, but there are no independent data from site-specific toxicity testing or quantitative population surveys that can confirm or refute the predicted risk from arsenic.

Based on this, it is concluded that arsenic in soil or sediment may pose a risk to some wildlife receptors, but that this conclusion should be considered tentative unless additional lines of evidence can be added to the evaluation.

#### **11.4 Viability of the Amphibian Community**

Table ES-10 summarizes data from the site that bear on the viability of amphibian receptors at the site. The observations are grouped to address each of the testable hypotheses, and important strengths and limitations in the available data are noted. Based on a consideration of all of the information, a weight of evidence conclusion is derived regarding each hypothesis.

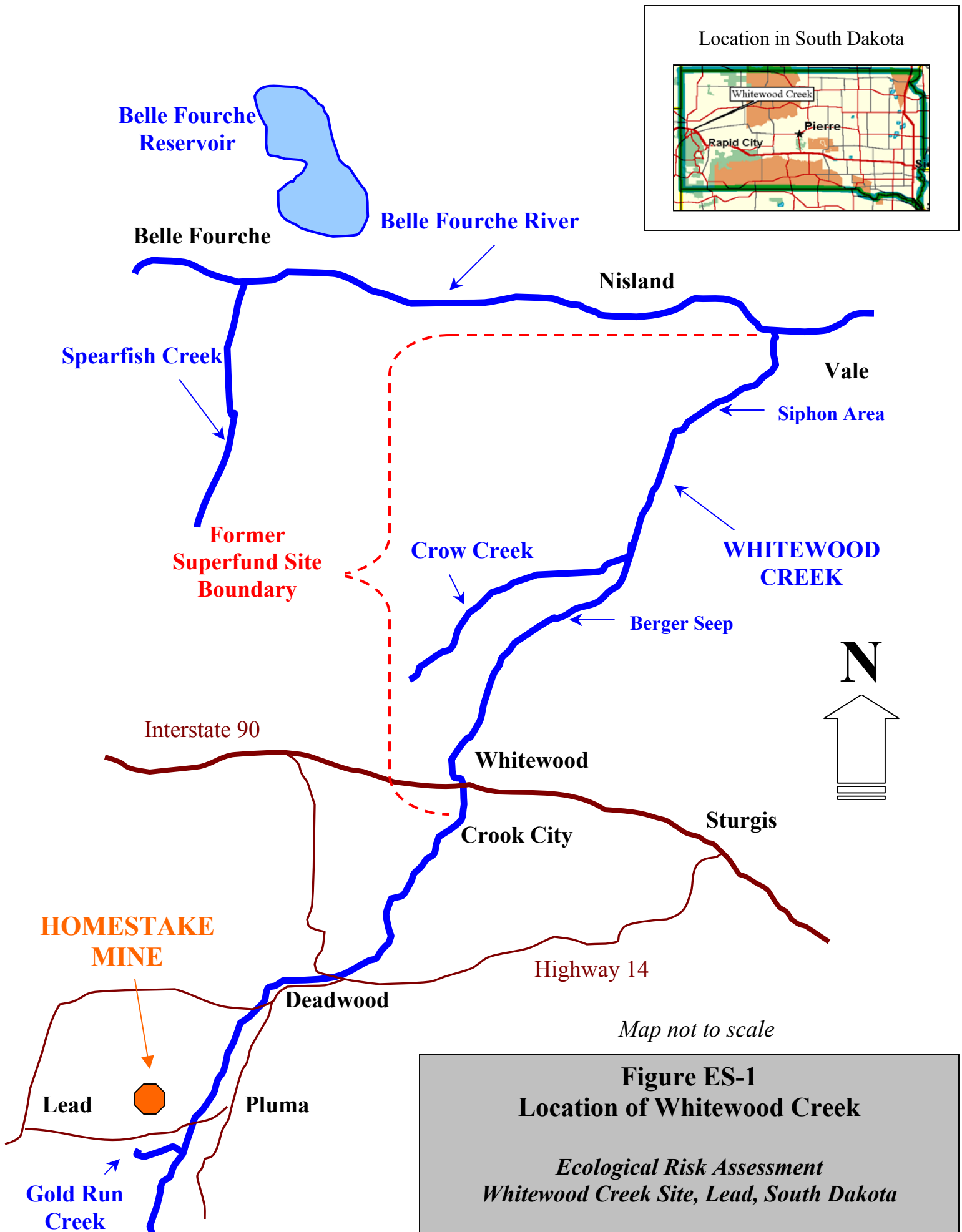
Table 11-8 combines data and conclusions across multiple testable hypotheses in order to reach overall conclusions regarding each hypothesis as well as an overall conclusion regarding risks to amphibians. Key conclusions are as follows:

- Some species of amphibians (but not all) may be at risk from dissolved COPCs in surface water.
- Risks from sediment or diet cannot be evaluated quantitatively, but are expected to be minor.

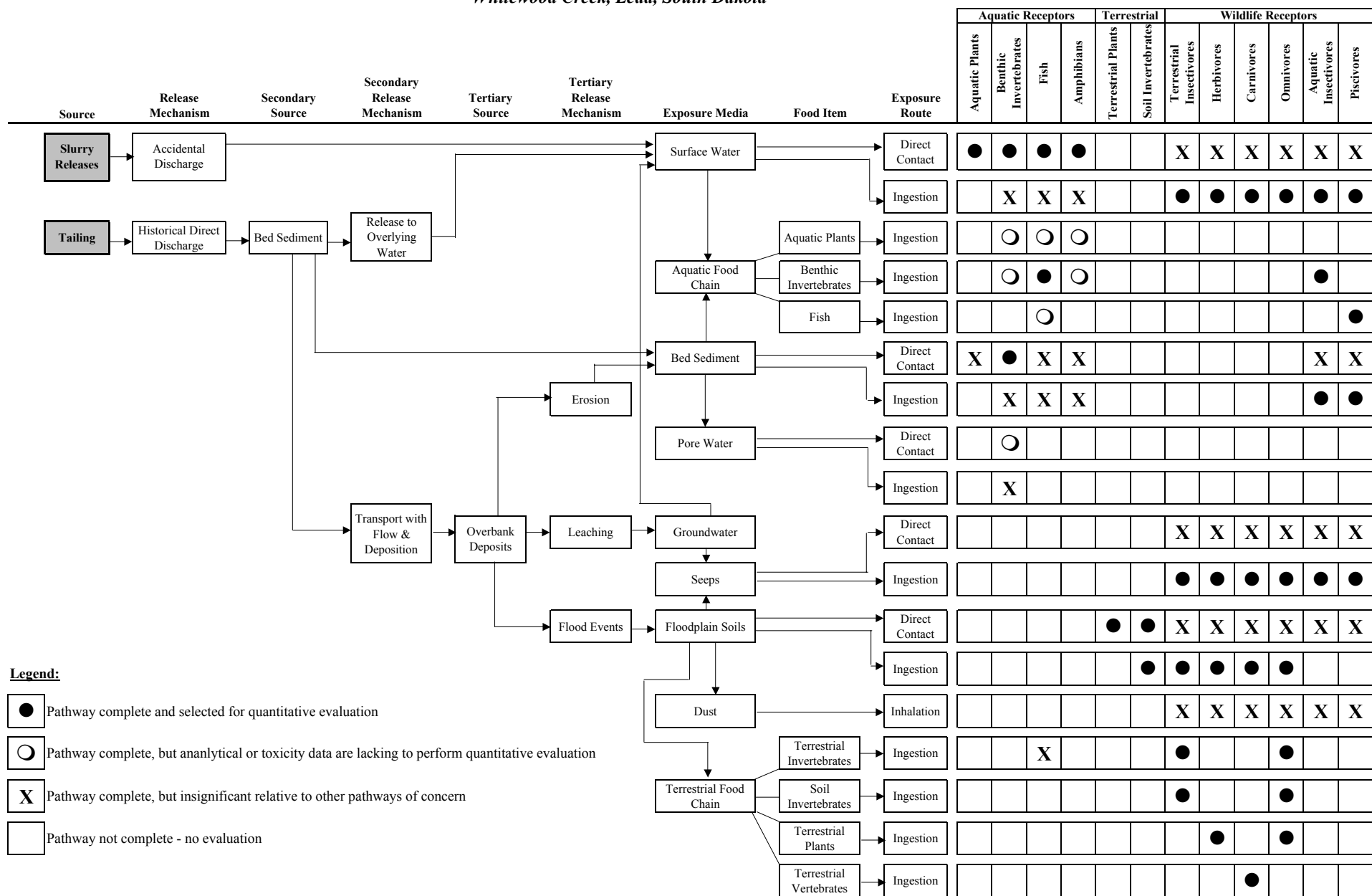
Based on this, it is concluded that risks to some amphibians are possible, but that this conclusion should be considered tentative unless additional lines of evidence can be added to the evaluation.

#### **11.5 Summary**

Substantial data are available to evaluate the potential risks of COPC-related toxicity to aquatic and terrestrial ecological receptors at the Whitewood Creek site. Based on an evaluation of the weight of evidence across all available lines of evidence, it is concluded that mining-related chemicals probably are causing some toxicological effects on both the aquatic and the terrestrial ecosystems, but that these effects are generally low level and are probably not sufficient to result in substantial disruption of either aquatic or terrestrial ecosystem function or viability.



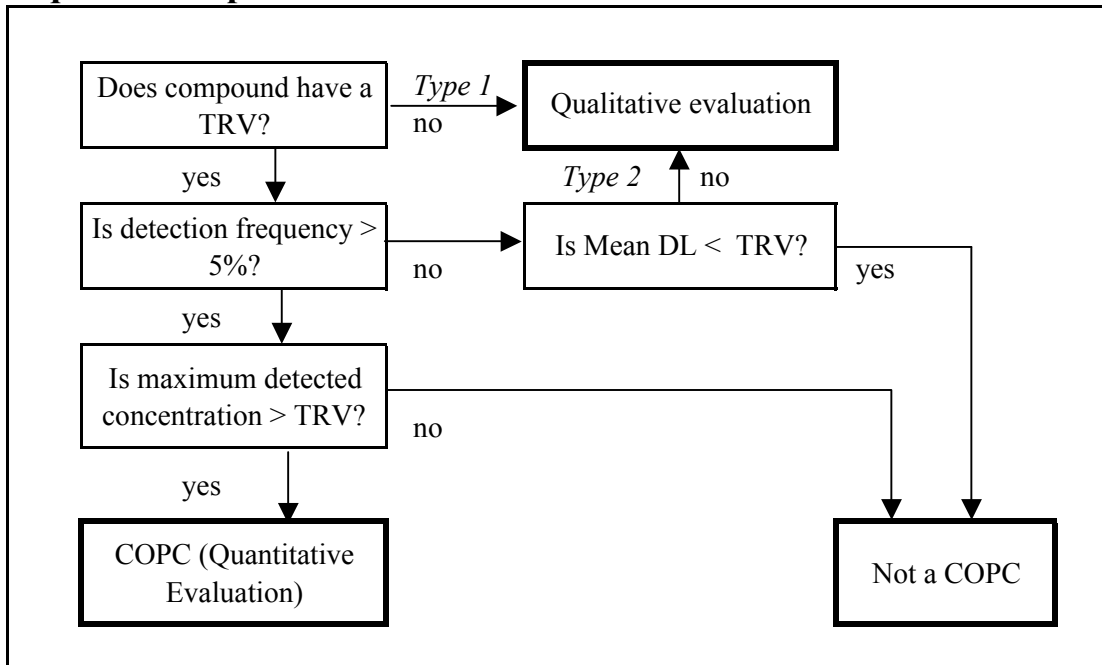
**Figure ES-2**  
**Ecological Site Conceptual Model**  
*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*



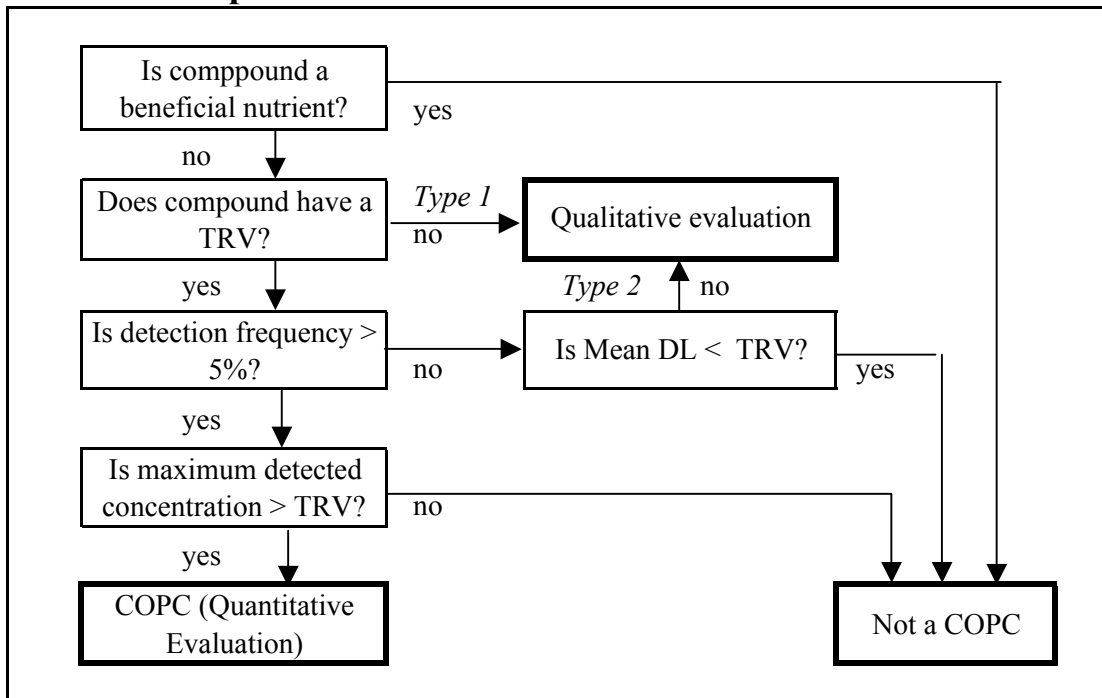
**Figure ES-3 COPC Selection Procedure**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

**Aquatic Receptors**



**Wildlife Receptors**



**Table ES-1**  
**Summary of COPCs Selected for Quantitative Analysis**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

Parameters	Aquatic Receptors		Wildlife Receptors			Plants & Soil Invertebrates
	Surface Water	Sediment	Surface Water	Sediment	Soil	Soil
Aluminum	X			X	X	X
Antimony				X	X	X
Arsenic		X	X	X	X	X
Barium				X	X	X
Beryllium					X	
Boron				X		X
Cadmium		X		X	X	
Chromium				X	X	X
Copper	X	X		X	X	X
Cyanide	X					
Iron						X
Lead	X	X		X	X	X
Manganese		X		X	X	X
Mercury		X		X	X	X
Molybdenum				X	X	X
Nickel		X				X
Selenium	X					
Silver	X					X
Thallium					X	X
Vanadium				X	X	X
Zinc		X	X	X	X	X
<b>Total</b>	<b>6</b>	<b>8</b>	<b>2</b>	<b>14</b>	<b>15</b>	<b>17</b>

**Table ES-2**  
**Assessment Endpoints and Associated Hypotheses and Measurement Endpoints**

*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*

Assessment Endpoint	Testable Hypothesis	Measurement Endpoint (s)
<b>Stream Function and Viability</b>  (The on-site instream habitat is not significantly degraded relative to the reference)	The concentrations of COPCs in sediment, porewater, and surface water on-site are not greater than benchmark values for toxicity to fish and benthic invertebrates.	Determine the concentrations of COPCs in sediment and compare to sediment toxicity benchmarks.  Determine the concentrations of COPCs in sediment porewater and compare to ambient water quality criteria (AWQC).  Determine the concentrations of COPCs in surface water and compare to AWQC and site-specific standards.
	The number of taxa and individuals in aquatic communities on-site are not significantly less than numbers at reference.	Compare the community data for periphyton, fish, and benthic invertebrates (number of taxa, individuals, and other metrics) to previous results and reference communities.
	The toxicity of COPCs in site sediment to benthic invertebrates is not significantly greater than reference.	Evaluate the toxicity of site sediment to the amphipod ( <i>Hyaella azteca</i> ) (growth and survival) through laboratory testing.  Evaluate the bioavailability of COPCs in sediment using both porewater and AVS/SEM measurements.
	The release of seep water is not significantly increasing the in-stream toxicity of surface water in WWC.	Determine the concentration of COPCs in water from seeps and compare to AWQC.  Evaluate the acute toxicity of seep water to the fathead minnow ( <i>Pimephales promelas</i> ) through laboratory testing.
	The concentrations of COPCs in benthic invertebrates and sediment on-site are not greater than toxicity benchmark values for ingestion by fish.	Determine the concentrations of COPCs in benthic invertebrate tissues and compare to toxicity benchmarks for fish ingestion.  Determine the concentrations of COPCs in sediment and compare to toxicity benchmarks for fish ingestion.
	The concentrations of COPCs in fish tissue on-site are not greater than toxicity benchmark values.	Determine the concentrations of COPCs in fish tissue and compare to toxicity benchmarks for fish tissue.
<b>Riparian Floodplain Function and Viability</b>  (The on-site riparian habitat is not significantly degraded relative to the reference)	The concentration of COPCs in on-site riparian floodplain soils and seep water is not greater than benchmark values.	Determine the concentrations of COPCs in soil and compare to toxicity benchmarks for plants and soil invertebrates.  Determine the concentrations of COPCs in interstitial seep water and compare to toxicity benchmarks for plants.
	The toxicity of riparian floodplain soils is not significantly greater than reference.	Evaluate the toxicity of COPCs from soil through solid-phase testing using earthworms.  Evaluate the toxicity of COPCs in soil through laboratory toxicity testing using plants.
	The number of vascular plant taxa on-site are not significantly less than the numbers at reference.	Compare the vascular plant community-types present on-site to reference.
	Soil function on site is not different than that at reference locations.	Compare the soil function parameters on-site to that at reference.

**Table ES-2**  
**Assessment Endpoints and Associated Hypotheses and Measurement Endpoints**

*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*

Assessment Endpoint	Testable Hypothesis	Measurement Endpoint (s)
<b>Viability of Insectivorous Wildlife</b>	The concentration of COPCs in food items of surrogate insectivorous wildlife species on-site is not significantly greater than reference.	Determine the concentrations of COPCs in soil, surface water, and sediment collected on-site and compare to those detected at the reference locations.  Determine the concentrations of COPCs in selected food items (earthworms and grasshoppers) and compare on-site concentrations to reference.
	The dietary exposure of surrogate insectivorous wildlife species to COPCs on-site is not greater than toxicity reference values.	Through food chain models for the cliff swallow ( <i>Petrochelidon pyrrhonota</i> ), American robin ( <i>Turdus migratorius</i> ), and the masked shrew ( <i>Sorex cinereus</i> ), estimate the daily dose of each COPC and compare to respective toxicity reference value (dose associated with no adverse effect). Compare results for on-site to reference.
	The body burden of COPCs in selected species on-site is not greater than reference.	Determine body burdens of COPCs in the masked shrew ( <i>Sorex cinereus</i> ) and/or other small mammals on-site and compare to reference.
	The body burden of COPCs in selected species on-site is not greater than benchmark values.	Determine body burdens of COPCs in the masked shrew ( <i>Sorex cinereus</i> ) and/or other small mammals on-site and compare to toxicity benchmarks for tissue burdens.
	The histopathology of organ tissues in selected species on-site is not significantly different from reference.	Determine the weights of liver, kidney and spleen in the masked shrew ( <i>Sorex cinereus</i> ) and/or other small mammals on-site and compare to reference.  Examine the liver, kidney and spleen in the masked shrew ( <i>Sorex cinereus</i> ) and/or other small mammals on-site for abnormalities and compare to reference.
<b>Viability of Herbivorous/ Omnivorous Wildlife</b>	The concentration of COPCs in food items of surrogate herbivorous and omnivorous wildlife species on-site is not significantly greater than reference or site-specific background.	Determine the concentrations of COPCs in soil, surface water, and sediment collected on-site and compare to those detected at the reference locations and background.  Determine the concentrations of COPCs in selected food items (plants) and compare on-site concentrations to reference.  Estimate concentrations of COPCs in food items and compare on-site concentrations to reference.
	The dietary exposure of surrogate herbivorous and omnivorous wildlife species to COPCs on-site is not greater than toxicity reference values.	Through food chain models for the meadow vole ( <i>Microtis pennsylvanicus</i> ) and deer mouse ( <i>Peromyscus maniculatus</i> ), estimate the daily dose of each COPC and compare to respective toxicity reference value (dose associated with no adverse effect). Compare results for on-site to reference.
	The body burden of COPCs in selected species on-site is not greater than reference.	Determine body burdens of COPCs in small mammals on-site and compare to reference.
	The body burden of COPCs in selected species on-site is not greater than benchmark values.	Determine body burdens of COPCs in small mammals and compare to toxicity benchmarks for tissue burdens.

**Table ES-2**  
**Assessment Endpoints and Associated Hypotheses and Measurement Endpoints**

*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*

Assessment Endpoint	Testable Hypothesis	Measurement Endpoint (s)
<b>Viability of Herbivorous/Omnivorous Wildlife (cont.)</b>	The histopathology of organ tissues in selected species on-site is not significantly different from reference.	Determine the weights of liver, kidney and spleen in the the meadow vole ( <i>Microtis pennsylvanicus</i> ) and deer mouse and/or other small mammals on-site and compare to reference.  Examine the liver, kidney and spleen in the the meadow vole ( <i>Microtis pennsylvanicus</i> ) and deer mouse ( <i>Peromyscus maniculatus</i> ) and/or other small mammals on-site for abnormalities and compare to reference.
<b>Viability of Carnivorous Wildlife</b>	The concentration of COPCs in food items of surrogate carnivorous species on-site is not significantly greater than reference or site-specific background.	Determine the concentrations of COPCs in soil, surface water, and sediment collected on-site and compare to those at reference.  Determine the concentrations of COPCs in selected food items (small mammals) and compare on-site concentrations to reference.  Estimate concentrations of COPCs in food items and compare on-site concentrations to reference and background.
	The dietary exposure of surrogate carnivorous species to COPCs on-site is not greater than toxicity reference values.	Through food chain models for the American kestrel ( <i>Falco sparverius</i> ), great horned owl ( <i>Bubo virginianus</i> ), and red fox ( <i>Vulpes vulpes</i> ), estimate the daily dose of each COPC and compare to respective toxicity reference value (dose associated with no adverse effect). Compare results for on-site to reference.
<b>Viability of Aquatic Insectivorous Wildlife</b>	The concentration of COPCs in food items of surrogate aquatic insectivorous wildlife species on-site is not significantly greater than reference or site-specific background.	Determine the concentrations of COPCs in soil, surface water, and sediment collected on-site and compare to those detected at the reference locations.  Determine the concentrations of COPCs in selected food items (aquatic invertebrates) and compare on-site concentrations to reference.  Estimate concentrations of COPCs in food items and compare on-site concentrations to reference.
	The dietary exposure of surrogate aquatic insectivorous wildlife species to COPCs on-site is not greater than toxicity reference values.	Through food chain models for the American dipper ( <i>Cinclus mexicanus</i> ), estimate the daily dose of each COPC and compare to respective toxicity reference value (dose associated with no adverse effect). Compare results for on-site to reference.
<b>Viability of Piscivorous Wildlife</b>	The concentration of COPCs in food items of surrogate piscivorous species on-site is not significantly greater than reference or site-specific background.	Determine the concentrations of COPCs in surface water and sediment collected on-site and compare to those at reference.  Determine the concentrations of COPCs in selected food items (fish) and compare on-site concentrations to reference.  Estimate concentrations of COPCs in food items and compare on-site concentrations to reference.

**Table ES-2**  
**Assessment Endpoints and Associated Hypotheses and Measurement Endpoints**

*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*

Assessment Endpoint	Testable Hypothesis	Measurement Endpoint (s)
<b>Viability of Piscivorous Wildlife (cont.)</b>	The dietary exposure of surrogate piscivorous species to COPCs on-site is not greater than toxicity reference values.	Through a food chain model for the belted kingfisher ( <i>Megaceryle alcyon</i> ) and the mink ( <i>Mustela vison</i> ), estimate the daily dose of each COPC and compare to respective toxicity reference value (dose associated with no adverse effect). Compare results for on-site to reference.
<b>Viability of Amphibian Community</b>	The concentrations of COPCs in surface water and seeps are not greater than benchmarks.	Determine the concentration of COPCs in surface water and seeps and compare to toxicity benchmarks.
	The toxicity of COPCs in on-site sediment is not significantly greater than at the reference.	Inference of sediment toxicity observed in macroinvertebrate exposures to amphibians.

**Table ES-3 Summary of Data Used in the Risk Assessment**

<b>Data Type</b>	<b>Medium</b>	<b>Location</b>	<b>Source</b>
COPC concentrations in abiotic media	Surface Water	Whitewood Creek, Belle Fourche River, Spearfish Creek	USGS and SDDENR (STORET) USEPA (2001a)
	Sediment	Whitewood Creek, Belle Fourche River, Spearfish Creek	USEPA (2001a)
	Seep Water	Whitewood Creek	USGS (2000) USEPA (2001a)
	Soil	Whitewood Creek, Belle Fourche River, Spearfish Creek	USEPA (2001b)
COPC concentrations in Biotic Tissues	BMI	Whitewood Creek, Belle Fourche River, Spearfish Creek	USEPA (2001a)
	Fish	Whitewood Creek, Belle Fourche River, Spearfish Creek	Chadwick(1996), USEPA (2001a)
	Plant, Grasshopper, Earthworm, Small mammals	Whitewood Creek, Spearfish Creek	USEPA (2001b)
	Birds	Whitewood Creek	Custer (1997)
Site-Specific Toxicity Tests	BMI ( <i>Hyaella azteca</i> )	Whitewood Creek, Belle Fourche River, Spearfish Creek	USEPA (2001a)
	Fish (fathead minnows)	Whitewood Creek	USGS (2000)
	Plant (turnip seed and rye grass seed)	Whitewood Creek, Spearfish Creek	USEPA (2001b)
	Earthworm	Whitewood Creek, Belle Fourche River, Spearfish Creek	USEPA (2001b)
Community surveys of density and diversity of ecological receptors	Aquatic community (fish, BMI, periphyton)	Multiple stations on Whitewood Creek, along with one or more reference locations	Chadwick (1990, 1997, 2001) Knudson (2000, 2001a, 2001b) USEPA (2001a)
	Plants (quantitative assessment of grassland, woodland/forest, and streamside vegetation)	Whitewood Creek	Harner and Associates (1991)
		Whitewood Creek, Spearfish Creek	USEPA (2001b)
	Soil Microbes	Whitewood Creek, Spearfish Creek	USEPA (2001b)
	Birds & Mammals	Whitewood Creek	Harner and Associates (1990a,b) Knowles 1996a,b)

**Table ES-4. Assessment of Testable Hypotheses for Stream Function and Viability**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

Testable Hypothesis	Measurement Endpoint	Observation	Effect Score	Discussion	Conclusion
The concentrations of COPCs in surface water on-site are not greater than benchmark values for toxicity to fish and benthic invertebrates.	Compare surface water COPC concentrations to AWQC (Figure 6-1).	Acute and chronic AQWC are sometimes exceeded for WAD cyanide downstream of Gold Run Creek.	+	The AWQC is based on free cyanide. HQ values based on WAD cyanide may overestimate hazard by an unknown degree.	Reject Hypothesis. Cyanide in surface water is not likely to cause effects on stockable trout, but might cause adverse effects to sensitive life stages of fish and benthic invertebrates. Other chemicals may cause intermittent low level stress.
		Occasional and generally low-level exceedences of chronic AWQC values occur for copper, lead and selenium.	+	These exceedances indicate that copper, lead and selenium in surface water could cause intermittent, low level stress.	
	Compare WAD cyanide surface water concentrations to species-specific value (Figure 6-2).	WAD cyanide concentrations exceed acute and/or chronic toxicity values for free cyanide for many fish species and some benthic invertebrate genus groups.	+	Most species-specific values are based on free cyanide. HQ values based on WAD cyanide may overestimate hazard by an unknown degree.	
	Compare surface water COPC concentrations to site-specific standards (Figure 6-3).	Site-specific standards are only rarely exceeded, and then by only a small amount.	-	Site-specific standards were developed to protect stockable size brown trout for periods of 90 days. These values might not protect more sensitive life stages of fish or some BMI.	
The concentrations of COPCs in sediment on-site are not greater than benchmark values for toxicity to benthic invertebrates.	Compare sediment COPC concentrations to toxicity benchmarks (Figure 6-5).	Predicted HQ values for sediment are generally below a level of concern for cadmium, manganese, nickel, and zinc.	-	Based on these comparisons, sediment toxicity is not predicted to be associated with these metals.	Reject Hypothesis. Sediment toxicity is predicted for Whitewood Creek sampling stations. Primary reason is elevated levels of arsenic. Other COPCs (copper, lead, mercury) might also contribute.
		HQ values for copper, lead, and mercury exceed a level of concern based on the lowest TRV but are of minimal concern based on the highest TRV.	+	Based on these comparisons, sediment toxicity from these chemicals is considered possible, but not certain.	
		Predicted HQs from arsenic are substantially above 1E+00 at all non-reference segments of Whitewood Creek and the Belle Fourche River, based on both the lower and upper toxicity benchmarks.	+	Arsenic is predicted to be associated with sediment toxicity.	
The concentrations of COPCs in sediment porewater on-site are not greater than benchmark values for toxicity to benthic invertebrates and fish.	Compare sediment porewater COPC concentrations to acute AWQC values and amphipod-specific acute TRVs	At locations where mortality was observed, concentrations of cadmium exceed acute AWQC but not amphipod acute TRV (Figure 6-6). Concentrations of arsenic exceed both benchmarks. Lead, copper and zinc exceeded the acute criteria at WWC-03, but no mortality was observed at those locations.	+	Arsenic levels could be responsible for the mortality. Cadmium might cause mortality in other receptors, but probably not <i>Hyalella</i> . Possible confounding by ammonia (see below). Porewater recovered from laboratory sediment toxicity tests may not reflect <i>in situ</i> porewater concentrations.	Reject Hypothesis. Sediment porewater could be toxic to BMI due to arsenic and possibly cadmium.

**Table ES-4. Assessment of Testable Hypotheses for Stream Function and Viability**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

Testable Hypothesis	Measurement Endpoint	Observation	Effect Score	Discussion	Conclusion
The number of taxa and individuals in the macroinvertebrate community on-site are not significantly less than numbers at reference	Compare the macroinvertebrate community (number of taxa, individuals, and other metrics) to reference communities	Whitewood Creek and Belle Fourche River benthic communities are slightly impaired relative to respective reference stations (Figure 6-9).	+	The slight impairment of the benthic community could be associated with increased metals in surface water and sediment. Levels tend to generally decrease as a function of distance downstream; proof of exposure by direct contact, sediment, and/or food web; not proof of toxicity.	Reject Hypothesis. Benthic communities in Whitewood Creek and the Belle Fourche river downgradient of the site are slightly impaired. The impairment could be related to increased metals and/or degradation of habitat quality (embeddedness) from tailings material.
		There is a reduction in the number of organisms per sample between WWC-02 upstream of Gold Run and WWC-03 downstream. The number of organisms remains small relative to reference downstream to WWC-09 (Figure 6-11).	+	There are no significant correlations between the concentrations of any of the COPCs and the individual benthic metrics or biological condition scores. An inverse association was noted for hardness.	
		Several metrics of BMI community status are correlated with habitat quality (embeddedness) (Figures 6-10 to 6-12).	-	Some of the impairment of the benthic community is likely associated with degradation of the habitat quality.	
The toxicity of COPCs in site sediment is not significantly greater than reference.	Evaluate the toxicity of site sediment to the amphipod ( <i>Hyaella azteca</i> ) (growth and survival) through laboratory testing.	The WWC-05 and WWC-06 test sediments reduced the survival of <i>H. azteca</i> . Growth of the surviving organisms was also significantly reduced in the WWC-05 sample (Table 6-10).	+	The results indicate that sediments from these locations on Whitewood Creek are toxic to aquatic invertebrates. Toxicity was not observed in other samples.	Reject Hypothesis. Sediments are toxic in some but not all locations. Arsenic, cadmium and/or mercury might be of concern at some locations, but confounding by ammonia prevents firm conclusion.
		An association was observed between mortality and concentrations of mercury in sediment and arsenic and cadmium in porewater (Table 6-11).	+	These results suggest that one or more of these metals might be responsible for the increased mortality in <i>Hyaella</i> .	
		An association was observed between mortality and concentrations of ammonia in porewater (Table 6-11).	-	The ammonia in the test chambers for WWC-05 and WWC-06 could be the cause of the observed toxicity	
	Evaluate the bioavailability of COPCs in sediment using AVS/SEM measurements.	The difference between SEM and AVS for most locations are negative (Table 6-5)	-	Based on excess AVS, sediment toxicity is not expected. Slight excesses (less than 1 umol/g) of SEM over AVS occurred at some stations, and BFR-11, but this excess is sufficiently small such that other binding agents (e.g., organic carbon) might be expected to attenuate exposures from any metals that may leach into porewater.	

**Table ES-4. Assessment of Testable Hypotheses for Stream Function and Viability**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

Testable Hypothesis	Measurement Endpoint	Observation	Effect Score	Discussion	Conclusion
The release of seep water is not significantly increasing the in-stream toxicity of surface water in WWC.	Determine the concentration of COPCs in water from seeps and compare to AWQC.	Most COPCs are below a level of concern even in the undiluted seep water. However, arsenic levels in seep water are often above the acute and/or chronic AWQC value, and aluminum and lead are above the chronic AWQC value in two locations (Table 6-12).	+	Undiluted seep water may be toxic to aquatic receptors. However, direct contact with undiluted seep water is not expected.	Accept Hypothesis. Under the conditions measured, the seeps are not expected to be toxic to freshwater fish and benthic invertebrates.
		Concentrations of COPCs in surface water downstream of seeps are often elevated compared to the upstream location. However, none of the elevations result in an exceedence of the acute or chronic AWQC values.	-	Seeps may be contributing to the metals load in the river, but because of dilution in the stream, seep releases are not likely to be a source of significant toxicity in surface water.	
	Evaluate the acute toxicity of seep water to the fathead minnow ( <i>Pimephales promelas</i> ) through laboratory testing.	The site-specific seep water samples are not acutely toxic to the fathead minnow after 96 hours of exposure in laboratory testing in any of the 5 seep water samples compared to reference (Table 6-14).	-	Fathead minnow may not be as sensitive as other species that reside in Whitewood Creek. Potential effects of chronic exposure are not evaluated by this test.	
The concentrations of COPCs in benthic invertebrates and sediment on-site are not greater than toxicity benchmark values for ingestion by fish.	Compare concentrations of COPCs in benthic invertebrate tissues to toxicity benchmarks for ingestion by fish.	HQ values do not exceed a value of 1E+00 for cadmium, copper, lead, or zinc, but do occasionally exceed a value of 1E+00 for arsenic (Table 6-6).	+	Most of the exceedences are based on the NOAEL-based TRV. Risks based on the LOAEL-TRV are mainly below a level of potential concern.	Accept Hypothesis. Adverse effects to fish resulting from ingestion of COPCs in food and sediment are not likely.
	Compare concentrations of COPCs in sediment to toxicity benchmarks for fish ingestion.	Concentrations of all COPCs in sediments at all stations are less than respective NOAEL-based and LOAEL-based toxicity benchmarks (Table 6-7).	-	Sediment intakes by fish are uncertain. Based on assumed intake rates, the ingestion of these metals in sediment is not predicted to cause adverse effects to fish.	
The concentrations of COPCs in fish tissue on-site are not greater than toxicity benchmark values for fish tissue.	Compare the concentrations of COPCs in fish tissue to toxicity benchmarks for fish tissue.	HQ values are consistently above 1E+00 for mercury and zinc (Table 6-9).	o	HQ values tend to be elevated for mercury and zinc at the reference locations as well as the site stations, suggesting the MATC values for these chemicals may be somewhat too low.	Accept Hypothesis. Data are too limited to support firm conclusion, but results suggest most fish do not have tissue burdens that are likely to be associated with toxicity.
		HQ values for arsenic exceed 1E+00 in a few samples of fish from the upper reaches of Whitewood Creek (Table 6-9).	+	Arsenic might be of concern to some individual fish but probably not all fish (the average HQ for arsenic for all fish excluding reference locations is 6E-01). Data are too limited and the values too variable to draw a firm conclusion	

**Table ES-5. Weight of Evidence Evaluation for Stream Function and Viability**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

Medium	Assessment Method	Conclusions	Weight of Evidence for Medium	Weight of Evidence for Ecosystem
Surface water	Predictive (HQ and HI approach)	Cyanide in surface water is not likely to cause effects on stockable trout, but might cause adverse effects to sensitive life stages of fish and benthic invertebrates. Other chemicals may cause intermittent low level stress.	Risks to fish and BMI from cyanide are possible, but magnitude is unknown. Impacts from other COPCs in surface water are likely low and intermittent.	Some effects of COPCs on stream viability and function may be occurring, but the impacts are sufficiently low that community and population level effects are not readily apparent.
	Site-specific toxicity testing	No toxicity observed for fathead minnows in water from 5 locations above and below seeps along Whitewood Creek.		
Sediment and porewater	Predictive (HQ and HI approach)	Sediment toxicity is predicted for BMI in Whitewood Creek sampling stations. Primary reason is elevated levels of arsenic. Other COPCs (copper, lead, mercury) might also contribute.	Risks to BMI are possible, but impacts from COPCs in sediment are likely to be restricted to a small number of locations.	
	Site-specific toxicity testing	Risks to BMI from sediments are low at most locations. Arsenic, cadmium and/or mercury might be of concern at some locations, but confounding by ammonia prevents firm conclusion.		
Seep water	Predictive (HQ and HI approach)	Undiluted seep water may be toxic to aquatic receptors. However, after dilution, risks are not predicted.	Risks from seep water are not of concern.	
	Site-specific toxicity Testing	Seep water samples are not acutely toxic to the fathead minnow.		
Diet	Predictive (HQ and HI approach)	Adverse effects to fish resulting from ingestion of COPCs in food and sediment are not likely.	Risks to fish from ingestion of aquatic prey items or sediment are not of concern.	
	Site-specific toxicity testing	No data		
All	Site-specific population observations	Tissue levels of arsenic exceed MATC in some fish, but average is below a level of concern. Population density and diversity of fish, BMI and periphyton are generally similar to other streams, and do not appear to be correlated with COPC levels.	Population level effects are not apparent.	

**Table ES-6. Assessment of Testable Hypotheses for Riparian Floodplain Function and Viability**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

Testable Hypothesis	Measurement Endpoint	Observation	Effect Score	Discussion	Conclusion
The concentration of COPCs in on-site riparian floodplain soils is not greater than phytotoxicity benchmark values (The on-site riparian habitat is not significantly degraded relative to the reference)	Compare the distribution of surface soil COPC concentrations to plant toxicity benchmarks (Figure 7-1).	For antimony, barium, copper, lead, mercury, molybdenum, nickel, silver, thallium, and zinc, most or all calculated HQs are below a level of concern.	-	These metals are not predicted to be associated with phytotoxicity.	Reject Hypothesis. Arsenic and perhaps manganese in site soils is predicted to be associated with phytotoxicity.
		HQs for aluminum, boron, chromium, and vanadium are greater than 1E+00 at all stations, including each of the reference locations.	o	This indicates that the phytotoxicity benchmark values for these chemicals are probably not appropriate for soil conditions in the Whitewood Creek study area and may over-predict risks.	
		For arsenic, HQ values are above a level of concern at all site locations, but are below a level of concern at all reference stations. Manganese is similar, but HQ values are lower.	+	Benchmarks are not site-specific and may not account for site-specific factors.	
The concentration of COPCs in on-site riparian floodplain soils is not greater than soil invertebrate benchmark values (The on-site riparian habitat is not significantly degraded relative to the reference)	Compare the distribution of surface soil COPC concentrations to soil invertebrate toxicity benchmarks (Figure 7-2).	HQ values are at or below a level of concern for barium, boron, copper, lead, mercury, molybdenum, nickel, silver, vanadium, and zinc.	--	These metals are not predicted to be associated with toxicity to soil invertebrates.	Reject Hypothesis. Arsenic in site soils is predicted to be associated with toxicity to soil invertebrates.
		HQs for aluminum, iron, and manganese are greater than 1E+00 at all locations, but the values at reference locations are generally similar to the site locations. A generally similar pattern is observed for chromium, although the HQ exceedences are lower.	o	Benchmark values for these chemicals may over predict risks and may not reflect soil conditions in the Whitewood Creek study area.	
		Arsenic HQs are above a level of concern at all site locations, and are below a level of concern at all reference locations.	+	Benchmark for arsenic is are not site-specific and may not account for site-specific factors.	
The concentration of COPCs in on-site seep water is not greater than phytotoxicity benchmark values (The on-site riparian habitat is not significantly degraded relative to the reference)	Compare seep water COPC concentrations (mean at sampling station) to plant toxicity benchmarks for solution exposures	All reported seep water concentrations of cadmium, copper, lead, mercury, nickel, selenium and zinc are lower than respective toxicity benchmarks.	-	Risk of phytotoxicity from these chemicals is not expected.	Reject Hypothesis. If plant roots are exposed to seep water, phytotoxicity from root exposure to arsenic could be occurring.
		Arsenic in seep water exceeds the screening benchmark at all sampling locations except the reference station.	+	Seep water may not be representative of soil water in the root zone. There is low confidence in the screening benchmark.	

**Table ES-6. Assessment of Testable Hypotheses for Riparian Floodplain Function and Viability**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

Testable Hypothesis	Measurement Endpoint	Observation	Effect Score	Discussion	Conclusion
The toxicity of riparian floodplain soils is not significantly greater than reference.	Evaluate the toxicity of COPCs from soil through solid-phase testing using earthworms. (Table 7-5).	None of the earthworms survived at WWC-05. This response is statistically significant (p < 0.05) compared to all reference soils.	++	Soils from other site locations did not cause mortality. This location or sample may be un-representative.	Accept Hypothesis. Site soils are not generally toxic to plants or soil invertebrates.
		Mean length and mean weight were not significantly different in worms exposed to WWC site soils compared to laboratory control soil or WWC reference soil. Compared to Spearfish Creek soil, there was a decrease in length for worms exposed for 14 days (but not 28 days) to soil from WWC-07, and an increase in weight loss for worms from WWC-08 and WWC-09.	-	There is no clear spatial pattern of toxicity and no apparent meaningful associations between any of the earthworm toxicity measurement endpoints and any of the COPCs in soil. This suggests that COPCs in site soil are probably not responsible for the observed earthworm toxicity.	
		The responses measured in the testing (mortality and growth parameters) could not be correlated with the concentration of the COPCs or other measured soil parameters.	-		
	Evaluate the toxicity of COPCs in soil through laboratory toxicity testing using plants.	Nearly all of the growth responses for rye grass seeds were not significantly lower than for seeds grown in soil from Whitewood Creek reference soil or laboratory control soil.	-	Based on the finding that growth of ryegrass in Whitewood Creek soils downstream from Gold Run Creek is not lower than for soil from a reference area upstream of Gold Run Creek and is also generally similar to laboratory control soil, and that no clear correlation between phytotoxicity and soil concentration of any COPC could be detected, it is concluded that riparian floodplain soils along Whitewood Creek are not significantly phytotoxic to plants.	
		Nearly all of the growth responses for seeds grown in WWC soils were significantly lower than for seeds grown in soil from Spearfish Creek.	+		
		No clear association was detected between soil levels of COPCs and measures of phytotoxicity.	-		
The number of vascular plant taxa and on-site are not significantly less than the numbers at reference.	Compare the vascular plant community-types present on-site to reference (Table 7-10)	Based on the Spearfish Creek site (18 total species), Whitewood Creek station WWC-05 is judged to be similar (21 species), while sites WWC-06 and WWC-08 are somewhat less diverse (10 species).	-	The plant data are qualitative in nature and do not support quantitative, statistical comparisons to reference.	Data are insufficient to support quantitative conclusion.
The soil community on-site is not different from that at reference locations.	Compare the soil function parameters on-site to reference.	Variabilty in many parameters is apparent as a function of location.	na	Information regarding interpretation of measured soil function parameters is not available; no comparison was performed.	Knowledge is insufficient to support a conclusion.

**Table ES-7. Weight of Evidence Evaluation for Riparian Floodplain Function and Viability**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

Medium	Assessment Method	Conclusions	Weight of Evidence for Medium	Weight of Evidence for Ecosystem
Site Soil	Predictive (HQ and HI approach)	Arsenic and perhaps manganese in site soils is predicted to be associated with phytotoxicity. Arsenic in site soils is predicted to be associated with toxicity to soil invertebrates.	Site soils are not generally toxic to plants or soil invertebrates.	Some effects of COPCs on riparian zone viability and function may be occurring, but the impacts are sufficiently low that community and population level effects are not readily apparent.
	Site-specific toxicity testing	Site soils are not generally toxic to plants or soil invertebrates.		
Seep water	Predictive (HQ and HI approach)	If plant roots are exposed to seep water, phytotoxicity from root exposure to arsenic could be occurring. Confidence in TRV is low.	If plant roots are exposed to seep water, phytotoxicity from root exposure to arsenic could be occurring, but confidence is low.	
	Site-specific toxicity Testing	No data		
All	Site-specific population observations	Plant population data are insufficient to support quantitative conclusion. Knowledge is insufficient to interpret soil microinvertebrate study .	Plant and microinvertebrate population data are insufficient to support a firm conclusion	

**Table ES-8. Assessment of Testable Hypotheses for Wildlife Viability**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

Testable Hypothesis	Measurement Endpoint	Observation	Effect Score	Discussion	Conclusion
The ingestion exposure of surrogate wildlife species to COPCs in on-site media (water, food, soil, sediment) is not greater than toxicity reference values.	Based on measured concentrations in site media, calculate doses of each COPC from each medium for each surrogate species and compare to respective toxicity reference value. Sum HQ results across pathways to estimate HI for each COPC. Compare results for on-site and reference (Appendix L).	For the great horned owl and the American dipper, predicted HI values do not exceed a level of concern for any COPC at any location.	-	No evidence of concern for these species.	Reject Hypothesis. Risks may be occurring to terrestrial wildlife species from incidental ingestion of arsenic in soil or sediment. Risks from food web exposure do not appear to be significant.
		Several COPCs (including aluminum, antimony, barium lead, manganese, molybdenum, thallium, and vanadium) are predicted to cause HI values above 1E+00 for one or more receptors, but in all cases the HI value exceeds a value of 1E+00 in one or more reference areas as well as site areas.	0	Occurrence of HI values above 1E+00 for reference areas suggests that the TRVs and/or the RBA values for these COPCs may be too conservative, since toxicity is not expected to be significant in reference areas. Thus, these HI values should be not be interpreted as strong evidence of potential harm.	
		Arsenic is predicted to cause HI values well above 1E+00 for a majority of receptors in most site exposure zones, but not in any reference zones. These elevated HI values are due almost entirely to ingestion of soil or sediment while feeding, with relatively little contribution from water or food web items.	+	Arsenic in soil or sediment might pose a health risk to a majority of wildlife receptors, including representatives of nearly all feeding guilds.	
The ingestion exposure of wildlife species to COPCs in on-site seep water is not greater than toxicity reference values.	Estimate the daily dose of each COPC for each surrogate species for ingestion of seep water and compare to respective toxicity reference value. Compare results for on-site and reference.	All HQ values for each COPC for each seep are less than or equal to one (Appendix L).	-	Seep water samples that have been collected may not represent all conditions.	Accept Hypothesis. Ingestion of COPCs in seep water is not likely to be of concern to wildlife receptors.
The body burden of COPCs in selected species on-site is not greater than reference.	Determine body burdens of COPCs in small mammals and birds on-site and compare to reference	Qualitative comparison of tissue burdens in tissues of small mammals does not reveal any clear differences for any COPC except arsenic (Appendix M).	-	COPCs other than arsenic are not likely to be of concern to small mammals.	Reject Hypothesis. Increased exposure of small mammals is occurring for arsenic.
		Concentrations of arsenic are higher in tissues from small mammals collected on site than for reference areas (Figure 8-2). Arsenic is also higher in most tissue and diet samples for birds.	+	The increased concentrations in on-site areas documents increased exposure but not necessarily increased adverse effects.	

**Table ES-8. Assessment of Testable Hypotheses for Wildlife Viability**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

Testable Hypothesis	Measurement Endpoint	Observation	Effect Score	Discussion	Conclusion
The histopathology of organ tissues in selected species on-site is not significantly different from reference.	Determine the weights of liver, kidney and spleen in small mammals on-site and compare to reference (Figure 8-3)	There is no clear difference in relative liver weights or relative kidney weights in small mammals collected from White Creek sites compared to reference sites.	-	These data do not indicate that COPC exposure is causing observable dysfunction in liver or kidney of small mammals. However, some adverse effects are not readily detected by routine gross or microscopic examination.	Accept Hypothesis. Available data do not indicate that COPCs are associated with significant pathology in small mammals.
		There is a tendency for relative spleen weights to be higher in animals from Whitewood Creek sites than reference locations.	o	The increase in spleen weight could not be correlated with concentrations of any COPC measured in tissue. The cause or significance of this observed effect is unknown.	
	Examine the liver, kidney and spleen in small mammals on-site for histological abnormalities and compare to reference (Table 8-8).	Apparent increased incidence of abnormal findings in animals from on-site compared to reference. Effects are not consistent across tissues or locations.	+	Lack of consistency decrease confidence that the effects are COPC related.	

**Table ES-9. Weight of Evidence Evaluation for Wildlife Viability**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

Medium	Assessment Method	Conclusions	Weight of Evidence for Medium	Weight of Evidence for Ecosystem
Surface water	Predictive (HQ and HI approach)	Predicted HQ values for ingestion of surface water are not of concern.	Risks to wildlife from surface water are not of concern.	Some effects of COPCs on terrestrial wildlife may be occurring, mainly from ingestion of arsenic. However, impacts are not certain and are probably sufficiently low that community and population level effects are not substantial.
	Site-specific toxicity testing	No data		
Soil and Sediment	Predictive (HQ and HI approach)	Predicted HQ values for ingestion of arsenic in soil or sediment are of concern in most locations for most receptors.	Risks to wildlife from arsenic in soil or sediment may be of concern.	
	Site-specific toxicity testing	No data		
Seep water	Predictive (HQ and HI approach)	Predicted HQ values for ingestion of seep water are not of concern.	Risks to wildlife from seep water are not of concern.	
	Site-specific toxicity Testing	No data		
Diet	Predictive (HQ and HI approach)	Predicted HQ values for ingestion of terrestrial prey items are not of concern.	Risks to wildlife from terrestrial prey items are not of concern.	
	Site-specific toxicity testing	No data		
All	Site-specific population observations	Available data do not indicate that COPCs are associated with significant pathology in small mammals.	Data do not reveal evidence of adverse effects, but ability to detect effects may be low.	
		Populations of birds and mammals are present, but data do not allow determination if levels are lower than expected.		

**Table ES-10. Assessment of Testable Hypotheses for Amphibian Viability**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

Testable Hypothesis	Measurement Endpoint	Observation	Effect Score	Discussion	Conclusion
The concentrations of COPCs in surface water are not greater than toxicity benchmarks for amphibians.	Compare the distribution of surface water COPC concentrations to amphibian toxicity benchmarks (Figure 9-1)	Concentration values of dissolved aluminum in surface water in Whitewood Creek might occasionally reach a level of concern for the Eastern narrow-mouthed toad. Other amphibian species for which toxicity data exist are not at risk from dissolved aluminum.	-	Because the concentration of aluminum shows little spatial pattern, aluminum concentrations are probably not substantially increased by mine-related releases.	Reject Hypothesis. Risks to amphibians from silver in surface water are possible in the upper portion of WWC. Other chemicals in surface water are not likely to be of concern, and seep water is not of concern.
		Concentrations of dissolved copper, lead, and selenium do not exceed a level of concern based for any of the amphibian species for which toxicity data are available.	-	Data do not suggest concern for amphibians for these metals.	
		Concentrations of dissolved silver reach or exceed a level of concern for two amphibian species (Eastern narrow-mouthed toad, common Indian toad) in the upper reaches of Whitewood Creek, but not at stations below the Berger Seep.	+	Silver in the upper reach might be of concern to some amphibian species.	
	Compare seep water COPC concentrations to amphibian toxicity benchmarks (Figure 9-2)	With the exception of a few data points for aluminum and one data point for lead, concentrations of COPCs in seep water are below a level of concern for all of the amphibian species for which TRVs could be located.	-	Data do not suggest concern for amphibians at seeps.	
The toxicity of COPCs in Site sediment is not significantly greater than at the reference.	na	na	o	No sediment toxicity benchmarks were located for amphibians. Risks from sediment contact is likely to be small compared to risks from contact with water.	Accept Hypothesis. Since risks from water appear to be generally low, risks from sediment are likely to be below a level of concern.

**Table ES-11. Weight of Evidence Evaluation for Amphibian Viability**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

Medium	Assessment Method	Conclusions	Weight of Evidence for Medium	Weight of Evidence for Ecosystem
Surface water	Predictive (HQ and HI approach)	Risks to amphibians from silver in surface water are possible in the upper potion of WWC. Other chemicals in surface water are not likely to be of concern.	Potential risks exist in upper reaches of WWC.	Although some effects are possible for some receptors, overall hazard does not appear to be substantial.
	Site-specific toxicity testing	No data		
Sediment	Predictive (HQ and HI approach)	Risks from sediment are likely to be below a level of concern.	Data are sparse, but effects are not expected.	
	Site-specific toxicity testing	No data		
Seep water	Predictive (HQ and HI approach)	Seep water is not of concern.	Effects are not expected.	
	Site-specific toxicity Testing	No data		
Diet	Predictive (HQ and HI approach)	No data	No data, but effects are likely to be low.	
	Site-specific toxicity testing	No data		
All	Site-specific population observations	No data	No data	

## **1.0 INTRODUCTION**

### **1.1 Purpose**

This document is a baseline ecological risk assessment (ERA) for the former Whitewood Creek Superfund Site, located near Whitewood, South Dakota (Figure 1-1). This ERA was completed as part of the five-year review process to help determine whether the remedial action specified for this site in 1990 (USEPA, 1990a) is protective of the environment.

### **1.2 Approach**

This ERA is completed in accordance with current United States Environmental Protection Agency (USEPA) guidance for performing ecological risk assessments (USEPA, 1992, 1997a, 1998). The general sequence of steps used to carry out an ERA at a Superfund site is illustrated in Figure 1-2 (USEPA, 1997a).

At this site, the ecological risk assessment process was initiated by performing a screening-level ecological risk assessment (SERA) in October of 1998 (ISSI, 1998). Because a SERA uses a number of simplifying assumptions and approaches and is intentionally conservative, the SERA was not intended to support any final quantitative conclusions about the magnitude of the potential ecological risks. Rather, the SERA provided preliminary information on the potential for adverse effects to aquatic receptors (including benthic invertebrates and fish) exposed via direct contact to chemicals of potential concern (COPCs) in surface water and sediments; to terrestrial plants exposed via direct contact to soils; to terrestrial soil invertebrates exposed via direct contact to soils; and to terrestrial wildlife receptors exposed via ingestion of surface water, sediments, soils, fish, benthic invertebrates, terrestrial plants and soil invertebrates. The SERA also identified data needed for the completion of a more detailed evaluation and made recommendations for the collection of these data.

Following completion of the SERA, several data collection efforts were conducted to support a more detailed and thorough evaluation of ecological impacts at the site. These efforts included the collection and chemical analysis of additional samples of environmental and biological media, a series of site-specific toxicity tests on sediment, soil, and seep water, as well as several surveys of aquatic community and habitat in Whitewood Creek and the Belle Fourche River.

The current baseline ERA report utilizes the new data along with the historical data to provide an updated and refined ecological risk evaluation for the site.

### **1.3 Organization**

In addition to this introduction, the ERA report is organized into the following main sections.

Section 2 - This section describes the location, environmental setting, and regulatory history of the Whitewood Creek Site.

Section 3 - This section presents the problem formulation for the baseline ecological risk assessment. This includes a summary of the conclusions of the SERA, the development of the site conceptual model, selection of the chemicals of potential concern, and definition of the assessment and measurement endpoints.

Section 4 - This section presents a summary of site investigations and studies conducted that help address the data gaps identified in the SERA.

Section 5 - This section discusses the available data for the Whitewood Creek Site, including a description of the nature and extent of heavy metal contamination present in both environmental and biological media.

Section 6 - This section presents an assessment of stream viability and function at the Whitewood Creek site. This includes a description of aquatic exposures, aquatic toxicity benchmarks, estimated Hazard Quotients, the results of site-specific toxicity testing, and the results of site-specific aquatic population surveys.

Section 7 - This section presents an assessment of the function and viability of terrestrial plants and soil invertebrates that reside in the riparian floodplain along Whitewood Creek. This includes a description of chemical concentrations in soil, toxicity benchmarks for plants and soil invertebrates, estimated Hazard Quotients, the results of site-specific toxicity testing, and the results of site-specific plant surveys.

Section 8 - This section presents an assessment of the viability of population of wildlife receptors that reside in the riparian zone along Whitewood Creek. This includes a description of estimated exposure levels, wildlife toxicity benchmarks, estimated Hazard Quotients, and the results of site-specific wildlife population surveys.

Section 9 - This section presents a screening level assessment of the viability of the amphibian community that resides along Whitewood Creek. This includes a

characterization of amphibian exposure levels, a summary of amphibian toxicity benchmarks, and presentation of estimated Hazard Quotients.

Section 10 - This section presents the uncertainties associated with the ERA and the potential impact of these uncertainties on risk estimates.

Section 11 - This section presents a weight of evidence based on the risk characterization for each assessment endpoint and an overview of conclusions of the ERA by each exposure medium.

Section 12 - This section provides citations for all data, methods, studies, and reports utilized in the ERA.

## **2.0 SITE CHARACTERIZATION**

### **2.1 Site Location**

The former Whitewood Creek Superfund Site is located in Lawrence, Meade and Butte Counties, South Dakota. The former National Priorities List (NPL) Site encompasses 18 miles of the 100 year floodplain of Whitewood Creek from the Crook City bridge near Interstate 90 to the confluence of Whitewood Creek and the Belle Fourche River (Figure 1-1). The NPL boundary was established based on the presence of tailing deposits along Whitewood Creek and was primarily based on human health risks from arsenic. This ecological risk assessment evaluates potential risks not only within the Superfund Site boundary, but also at upstream and downstream locations on Whitewood Creek and along the Belle Fourche River. In this document, this larger area is referred to as the "site" or "study area", while the sub-area comprising the former Superfund site is referred to as the "NPL Site" .

### **2.2 Site Description**

A large gold mine operated by Homestake Mining Company (HMC) is located in Lead, South Dakota near the headwaters of Whitewood Creek. Mining operations over the last century have produced about 1,000,000,000 tons of ore from both open pit (Figure 2-1) and subsurface workings (Fox Consultants, Inc., 1984a). During the period between 1870 and 1977, tailings generated during the operation of the mine were released into Gold Run Creek, which drains directly into Whitewood Creek between the towns of Lead and Deadwood (Figure 2-2). Since 1977, residual slimes and process water have been piped to the Grizzly Gulch tailings impoundment in the upper reaches of the Whitewood Creek watershed. Beginning in 1984, a wastewater treatment plant has treated water from the tailings impoundment and mine. Solids are returned to the tailings pond and water enters Gold Run Creek . This discharge is monitored by a Surface Water Discharge permit (Permit No. SD-0000043) (USEPA, 1990a).

#### Stream Morphology

Deposition of tailings altered the morphology of Whitewood Creek. Before tailings were deposited, Whitewood Creek was reportedly a typical Black Hills ephemeral stream with a thin layer of alluvium deposited over bedrock (USEPA, 1989a). It is estimated that approximately 25 to 37 million tons of tailings were deposited in the floodplain (ICF, 1989). The large mass of tailings transported in the Whitewood Creek basin resulted in a series of depositional and erosional events that distributed tailings throughout the flood plain. In their upper reaches, Gold Run Creek and Whitewood Creek are rather steep, and most of the tailings were carried

downstream by the flow of the water. Near Crook City, the gradient of Whitewood Creek becomes less steep, allowing the tailings to become deposited along the banks and in the creek sediment.

Currently, Whitewood Creek has eroded through the tailings to or near shale bedrock and the stream is braided over much of the study area (USEPA, 1989a; ICF, 1989). When aggradation of the streambed lessened in the early 1900's, overbank deposits were stabilized in places with vegetation (USEPA, 1989a). Tailing deposits clearly extend to the Belle Fourche River and downstream to the Cheyenne River.

The feasibility study (ICF, 1989) describes the stratigraphy of the tailing deposit areas as: 1) an upper deposit of tailings ranging from approximately one to fifteen feet thick and fifty to several hundred feet wide on each side of the creek along its full 18 mile length within the Site, 2) an underlying strata of natural alluvium consisting of sandy to sandy silt materials with variable amounts of intermixed tailings, and 3) the thick shale strata that forms the floor of the valley (Figure 2-3).

### Mining Processes

The first milling methods at HMC were primitive and non-mechanized. Gold was recovered by using crude methods of crushing with recovery by gravity or mercury amalgamation. By 1880, the early non-mechanical methods were replaced with more than 1,000 stamp mills (large blocks of cast iron or steel dropped onto replaceable anvils) that crushed the ore to a coarse sand size. The tailings were then discharged to Whitewood Creek or its tributaries. Prior to the turn of the century, much of the ore consisted of near surface, red-colored minerals that were residual oxidation products of the arsenopyrite, pyrrhotite, and pyrite mineralization of the original unoxidized ore bodies (Fox Consultants, Inc., 1984a; Chadwick Ecological Consultants, Inc., 1997). After the turn of the century, the black and green-colored reduced ores from deeper in the mine (below the zone of oxidation) were the focus of the mining activity. These ores contained large percentages of reduced oxidation-state minerals, including arsenopyrite and pyrrhotite.

The use of ball and rod mills, brought into service in the 1920s, created finer-grained tailings referred to as "slimes". As the mining went deeper, maintenance of the structural integrity of the mine walls necessitated backfilling with the coarse (sand-sized) portion of the tailings.

Until 1977 (with the exception of five years of closure during World War II), the "slimes" and some coarse-grained sands, continued to be discharged directly into Gold Run and thereby into Whitewood Creek. Discharge from a number of sources ceased in approximately 1920, when

HMC became the only remaining source of tailings discharge. In 1977, HMC constructed a tailings impoundment in the upper reaches of the watershed and tailings discharges to the creek ceased (Chadwick Ecological Consultants, Inc., 1997).

Presently, ore is milled in crushers and rod and ball mills. The material from the milling process is separated into two size fractions, sand and slimes. These fractions are treated separately by cyanide leach and carbon filter methods. Residual sand material is used to backfill within the mine. Residual slimes and process waters are piped to the Grizzly Gulch tailings impoundment in the upper reaches of the Whitewood Creek watershed. The tailings disposal system became operational in 1977, resulting in cessation of direct discharge of tailings to Gold Run Creek (Chadwick Ecological Consultants, Inc., 1997).

Mercury amalgamation of the ores was used over the greater period of the mining operation and was discontinued in January of 1971. Quotes on the volumes of mercury used and lost to the waste stream in this process vary from an eighth of an ounce to almost half an ounce per ton of ore crushed with almost 50 percent of this volume lost to the entire waste stream. Cyanide has also been used in the gold recovery process since the early 1900's to process the lower grades of ore and increase gold and silver recoveries. Since the cessation of mercury use in 1971, cyanide has been used exclusively for gold recovery. The tailings also contain considerable quantities of arsenic that are derived from minerals in the ore (Fox Consultants, Inc., 1984a).

### Waste Water Treatment Processes

In 1984, a wastewater treatment plant began treating water from the tailings impoundment and mine. The plant uses rotating biological contactors to remove cyanide and ammonia; iron precipitation and sorption to remove metals; and sand filtration to remove suspended solids. Solids are returned to the tailings pond. Water enters Gold Run Creek and discharges into Whitewood Creek between the towns of Lead and Deadwood. This discharge is monitored to meet requirements of the Clean Water Act (Chadwick Ecological Consultants, Inc., 1997).

## **2.3 Basis of Potential Concern**

### Tailings Deposits

Tailings (finely ground rock containing residual metallic and nonmetallic compounds not extracted from the ore and trace compounds used in the extractive processes) were transported away from the mine by disposal into surface water. Reports indicate that in 1963 as much as 3,000 tons per day of tailings, together with 12,500 tons per day of water, were being discharged

to Gold Run Creek (Fox Consultants, Inc., 1984a). The tailings material was transported by the creek flow and deposited downstream from the mine with the larger deposits along the banks of Whitewood Creek between the Crook City Bridge and the confluence with the Belle Fourche River (Figure 1-1). Tailings remain along much of this reach of Whitewood Creek as depicted in the photographs shown in Figure 2-4.

### Slurry Releases

In addition, several documented fish kill events along Whitewood Creek have been associated with slurry releases from the mine. Recently, two such events have been reported to the SDDENR and the USEPA. Details regarding these releases are located in the Notice of Violation and Order and the Settlement Agreement and are summarized below (SDDENR, 1998a, 1998b).

On November 25, 1997, approximately 100 gallons of slurry containing mine wastes and wood chips (15-20 mg/L cyanide) were accidentally released from the Kirk bore hole. After flowing overland, the slurry flowed directly into Whitewood Creek. The majority of fish mortality was seen about 150 to 2,000 feet downstream of the release (65 dead trout).

On May 29, 1998, approximately 10,000 gallons of mill tailings and process solution containing cyanide and heavy metals (20 mg/L cyanide) was released from the west sand plant into a storm sewer that discharges into Gold Run Creek. The slurry flowed down Gold Run Creek about one-half mile and into Whitewood Creek. The slurry release produced discoloration, sludge deposits, and sediments in Gold Run Creek and Whitewood Creek. HMC estimated that 10 to 12 tons of tailings were released, about 1 to 2 pounds of weak-acid dissociable cyanide. However, HMC later reported that 12 to 15 tons of tailings were removed from Gold Run Creek, not including the Whitewood Creek tailings; therefore, the estimate of 10 to 12 tons is thought to be low.

In June 1998, OEA Research Consultants (hired by HMC) conducted an assessment of the aquatic life in Whitewood Creek to evaluate the effects of the May 29, 1998 release. This assessment estimated that 1,035 to 2,995 brook trout, brown trout, longnose dace, and mountain suckers were killed between the Whitewood Creek tunnel in Deadwood and the confluence of Gold Run Creek. Although dead fish were also observed in Whitewood Creek below the confluence with Gold Run Creek, quantitative estimates were not available.

As a results of these releases, SDDENR ordered HMC to conduct aquatic assessments (biannually for three years) of Whitewood Creek to ensure that the 1997 and 1998 releases resulted in only short-term aquatic impairment. These results of these aquatic assessments will be discussed further in the evaluation of risks to the aquatic communities of Whitewood Creek.

According to the settlement agreement, Homestake was also required to pay \$150,000 to SDDENR for civil penalties and \$50,000 to the city of Lead, South Dakota, for the separation of the combined sewer system in Lead.

## **2.4 Site Regulatory History**

The Whitewood Creek Site was nominated for the NPL in 1981 and was listed on the NPL in 1983. In 1985, an endangerment assessment (EA) was initiated and completed in 1989 by Jacobs Engineering (USEPA, 1989a; Jacobs Engineering, 1989). The feasibility study (FS) was completed in 1989 and the Record of Decision (ROD) was issued in 1990 (ICF, 1989; USEPA, 1990a). Clean up of residential area soils was completed in 1992. Institutional controls were in place by 1994 and the Site was removed from the NPL in 1996. Table 2-1 lists the activities and reports associated with the Superfund Process completed at the Whitewood Creek Site. Appendix A presents summaries of many of the key investigations and the principle regulatory documents associated with the Site.

The studies used as the basis of the ROD (Fox Consultants, Inc., 1984a and Jacobs Engineering, 1989) did not, in general, meet the requirements of guidelines for risk assessments and Remedial Investigations (RI) available at the time of completion (USEPA, 1988). The RI/FS guidance specified that existing data should be collected and analyzed to develop a site conceptual model to be used to assess the nature and the extent of contamination and to identify potential exposure pathways and potential human health and/or environmental receptors (USEPA, 1988; pgs 2-2 and 2-8). The guidelines also stated that the location of any threatened, endangered or rare species, sensitive environmental areas or critical habitats on or near the Site should be identified (USEPA, 1988; pg 2-7). These tasks (site conceptual model, risk assessment components, and identification of rare, endangered and threatened species) were not completed in the risk assessments prior to the ROD.

Several guidelines for ecological risk assessment have been issued since these risk evaluations were completed. Some of the guidance materials include:

*Risk Assessment Guidance for Superfund Volume II: Environmental Evaluation Manual* (USEPA, 1989b)

*Framework for Ecological Risk Assessment* (USEPA, 1992)

*Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final* (USEPA, 1997a)

The available guidance consistently recommends completion of an ecological risk assessment (ERA) that includes four primary components; Problem Formulation, Exposure Assessment, Effects Assessment, and Risk Characterization, and is completed according to an established 8-step process (Figure 1-2; USEPA, 1997a). This ERA serves to complete these required steps for the Whitewood Creek Site.

## **2.5 Site Environmental Setting**

### **2.5.1 Physical Setting**

Whitewood Creek flows northeast from its source in the Black Hills of South Dakota past the Homestake Mine and the towns of Lead, Deadwood and Whitewood before joining the Belle Fourche River on the Missouri Plateau. The Belle Fourche River joins the Cheyenne River approximately 130 miles further downstream (Fox Consultants, Inc., 1984a).

Prior to the initiation of tailings discharge, Whitewood Creek was a small stream with insufficient capacity to move large quantities of sediment. As tailings were released into the stream, the length of the stream channel diminished, primarily through meander abandonment, thereby increasing the stream gradient and thus the stream sediment carrying capacity. Abandoned meanders were filled with tailings and natural alluvium. Successive layers of these sediments were deposited in overbank areas, particularly during periods of ice jamming. As the meanders were being abandoned, the stream began a period of down cutting along the course of the present channel. Down-cutting was limited by resistant coarse alluvial deposits and by shale outcrops that form the streambed in many places (Fox Consultants, Inc., 1984a).

The present course of Whitewood Creek in the upper reaches of the site is comparatively straight with few meanders and few bends. In the lower reaches, the channel is a 4-braided pattern with occasional bends or meanders. Although the present channel is not entirely stable, many of the overbank terraces and abandoned meanders have tailings deposits that have been stable for many decades. A dense cover of leaf mulch, grass, and mature trees, some of which are 2 feet in diameter, exist on many of these stable areas (Fox Consultants, Inc., 1984a). Figure 2-5 provides photographs of Whitewood Creek from the Crook City bridge to the confluence with the Belle Fourche River. These photographs are keyed to a general map showing the location of the photograph.

### 2.5.2 Vegetative Cover

Vegetative communities along Whitewood Creek change between the upper and lower portions of the stream. Fox Consultants, Inc. (1984a) characterized the vegetative communities as two zones, with plant communities exhibiting relatively constant species composition within each of the two zones.

The first zone encompasses the upper portion of the stream, from the headwaters down to the confluence with Crow Creek (Figure 1-1). In this zone, the topography is steeper and more broken with floodplain width being more restricted. Woodland composition is dominated by bur oak with the plains cottonwood and narrow leaf cottonwood occurring in relatively small quantities. Some ponderosa pine occurs on the edge of the floodplain, near Crook City (Fox Consultants, Inc., 1984a).

The second zone extends northwards along Whitewood Creek and then eastward along the Belle Fourche River. Basic vegetation characteristics change in response to elevation and topography. The reduced gradients and lower elevations downstream of the Whitewood Creek-Crow Creek confluence encourage an increase in the occurrence of American elm, box elder, green ash, and a decrease in importance of bur oak. Cottonwoods and willow attain greater frequency as the transition occurs from the broken terrain of the foothills to the relatively level terrain of the plains. Plains cottonwood and willow dominate the riparian woodlands, with the comparative abundance of willow and cottonwood depending on local hydrology. Russian olive appears as a minor species upstream becoming increasingly more prevalent downstream (Fox Consultants, Inc., 1984a). Seedlings and saplings of the over story species typically dominate under story vegetation. Snowberry was a common shrub and perennial grasses were the prevalent ground cover. Dominant grasses included blue grass, wheatgrass, smooth brome, and prairie cordgrass (Fox Consultants, Inc., 1984a).

The riparian corridor along the Belle Fourche River is more fragmented than Whitewood Creek due to more intense agricultural activities. Fields adjacent to the river are used for crops (alfalfa, corn, and hay), or for rangeland used for livestock grazing. Over-grazing by livestock (cattle and sheep) was apparent along some stream stretches (Fox Consultants, Inc., 1984a). Consequently, the riparian understory is less well developed, tree size is greater, fewer species are present, and the overhead tree canopy is more open. Cottonwood, willow, Russian olive, green ash, and box elder are the primary overstory and understory species (Fox Consultants, Inc., 1984a).

Although some tailings deposits remain barren, it is reported that a plant community with limited diversity has gradually colonized the tailings (USEPA, 1990a). The barren areas have been

invaded by rhizomatous grasses, forbs and small shrubs (USEPA, 1989a). Succession appears to begin when grasses take root in leaf litter trapped in depressions in the surface of the tailings. Some trees in the tailings deposits have been dated at over 100 years old (Batt, 1988).

### **2.5.3 Aquatic Ecology**

Herricks (1982) characterized Whitewood Creek as flowing through three ecological zones. The upper third of the creek was described as a cold, fast-flowing water with the fish community dominated by cold-water species. The middle third of the creek (corresponding to the upper half of the former NPL Site) was described as a transitional area where the water becomes warmer and has more pools and riffles, providing a transition to more warm-water species. The lower third of the creek (corresponding to the lower half of the former NPL Site) runs onto a low-gradient landscape before emptying into the Belle Fourche River, and is dominated by warm-water fish species. The Belle Fourche River in the study area is relatively wide, low gradient stream, with somewhat less riparian development.

The identity and density of aquatic species in Whitewood Creek have been investigated by Chadwick and Associates (1990a,1990b, 2001) and by Knudson (2001a, 2001b). Both investigators performed surveys of the periphyton, benthic, and fish communities present at multiple locations and multiple times along Whitewood Creek. While the number of species and density of individuals varied between studies and as a function of time and location, both series of surveys indicate that Whitewood Creek usually contains a diverse community of aquatic species.

The periphyton community is usually characterized by about 30-50 species of algae (Knudson, 2001a, 2001b; Chadwick and Associates, 1990a,1990b). These are predominately diatoms, but some filamentous algae are also present (Chadwick and Associates, 1990a,1990b).

The benthic community in Whitewood Creek is generally characterized by about 40-70 different taxa of invertebrates (Chadwick and Associates, 1990a,1990b, 2001; Knudson 2001a, 2001b). These are mainly aquatic insects (including representatives of each of five different feeding groups), along with some worms, clams and snails (Knudson 2001a, 2001b).

A total of 15 different fish species have been reported to occur in Whitewood Creek, with the most common being brown trout, brook trout, white sucker, mountain sucker, and several species of minnows (longnose dace, creek chub, flathead chub, sand shiner, and fathead minnow) (Chadwick and Associates, 1990a,1990b, 1997, 2001; Knudson, 2001a, 2001b). Age class analysis of brown trout populations suggest this species is reproducing naturally (Knudson

2001a, 2001b). Table 2-2 summarizes the fish species that have been observed in Whitewood Creek and the Belle Fourche River.

Section 6 employs the data from these studies as part of a weight-of-evidence evaluation of the potential impacts which mining related wastes and releases may be having on the aquatic community.

#### **2.5.4 Terrestrial Ecology**

##### Amphibians and Reptiles

Systematic surveys of amphibians and reptiles within the study area are not available. Harner and Associates (1990a and 1990b) and Knowles (1996a) provide information on incidental observations of amphibian and reptile species made during surveys for birds and mammals. The amphibian and reptile species observed within the Whitewood Creek study area are listed in Table 2-3.

##### Birds

Bird surveys have been completed at the site by Harner & Associates (1990a and 1990b) and by Knowles (1996b). The surveys included information from multiple observation stations established in riparian habitat along Whitewood Creek and in grassland habitat adjacent to Whitewood Creek. Avian species observed during these surveys are listed in Table 2-4.

##### Mammals

Wildlife surveys completed in the fall of 1996 included small mammal live trapping, pit traps, examination of pellet group transects, night-time spotlighting for deer, and general observations. The mammalian species identified during these surveys as well as those species previously identified in 1989 and 1990 (Harner & Associates, 1990a and 1990b) are listed in Table 2-5.

#### **2.5.5 Rare, Endangered and Threatened Species**

Knowles (1996a) identified 12 Federal and South Dakota State listed threatened and endangered vertebrate wildlife species that could potentially occur in Whitewood Creek site. Only one species, the bald eagle, is documented occur in the site. Table 2-6 lists the species along with their respective state and federal status.

### **3.0 PROBLEM FORMULATION**

Problem formulation is a systematic planning step that identifies the major factors to be considered in the ERA (USEPA, 1997a). Problem formulation usually begins by development of a conceptual site model that identifies sources of chemical release to the environment, evaluates the fate and transport of chemicals in the environment, and identifies exposure pathways of potential concern for ecological receptors. Based on the conceptual site model, assessment endpoints and testable hypotheses are identified that form the basis of the ERA.

As discussed in USEPA guidance (USEPA, 1997a), problem formulation is an iterative process, undergoing refinement as new information and findings become available. The problem formulation for this baseline ecological risk assessment began with a screening-level ecological risk assessment (SERA) that was completed for the site in October, 1998 (ISSI, 1998). The purpose of the SERA was to determine if there was a need for additional data collection and/or additional risk assessment at the site, and to help focus any additional effort on the main issues of concern. Because a SERA is intentionally simplistic and conservative, it is not intended to support any final quantitative conclusions about the magnitude of the potential ecological risks identified. The following section summarizes the main findings of the SERA, which in turn help define the problem formulation for the baseline risk assessment.

#### **3.1 Summary of Screening Ecological Risk Assessment (SERA)**

##### Primary Sources

The primary sources that were evaluated in the SERA were tailings that exist along the banks of Whitewood Creek, as well as chemicals that exist in the water and sediment of the Creek.

##### Chemicals of Potential Concern

The main chemicals of potential concern at mining sites are inorganics, including metals in the ore that is mined and processed, as well as chemicals that are used to extract metals from the ore. The following chemicals were selected for evaluation in the SERA:

- |            |            |
|------------|------------|
| • Arsenic  | • Lead     |
| • Cadmium  | • Mercury  |
| • Chromium | • Nickel   |
| • Copper   | • Selenium |
| • Cyanide  | • Zinc     |

### Ecological Receptors of Potential Concern

Ecological receptors evaluated in the SERA included aquatic species (fish and benthic macroinvertebrates) residing in Whitewood Creek, and terrestrial receptors (plants, soil invertebrates, birds, wildlife) that reside in the riparian zone adjacent to Whitewood Creek.

### Exposure Pathways Evaluated

Exposure pathways that were quantitatively evaluated in the SERA included:

- Direct contact of aquatic receptors (fish, BMI, periphyton) with surface water
- Direct contact of BMI with sediment
- Direct contact of terrestrial plants with soil
- Direct contact of soil invertebrates with soil
- Ingestion of surface water, sediment, soil by avian and mammalian wildlife
- Ingestion of food items (fish, BMI, terrestrial plants, soil invertebrates) by avian and mammalian wildlife

### Summary of Screening-Level Risk Findings

A summary of the screening level risk findings presented in the SERA is provided in Table 3-1. Based on the preliminary risk characterization in the SERA, none of the exposure pathways considered in the SERA could be excluded, and further evaluation was recommended for all exposure pathways.

### Summary of Data Gaps

The SERA identified a number of data areas where additional information was needed to help improve the reliability and accuracy of the risk assessment. A summary of these data gaps and recommendations for data collection activities is provided in Table 3-2. These data gaps were considered in the development of a field sampling Quality Assurance Work Plan (QAWP) (ERT, 1999a) and Data Quality Objectives (DQOs) (ERT, 1999b).

## **3.2 Baseline Risk Assessment Site Conceptual Model**

Figure 3-1 presents the conceptual model for the baseline ecological risk assessment. Because no pathways could be excluded as a result of the SERA, this site model is very similar to the site

model that was developed for the SERA. The main features of the conceptual model are summarized below.

### Sources and Transport Pathways

As described previously, the historical release of tailings directly to Whitewood Creek resulted in their deposition as bed sediments and overbank and floodplain deposits along Whitewood Creek and the Belle Fourche River. Tailings deposited as bed sediments may release chemicals to the overlying surface water and interstitial pore water. Tailings deposited in overbank and floodplain soils may leach chemicals to groundwater which could be transported to surface waters and seeps. Overbank tailings deposits may also collapse and erode into the stream, resulting in on-going release of chemicals on suspended particles to surface water and sediments. Chemicals that are present in surface waters, sediments, and soil may be accumulated within the aquatic and terrestrial food chains, leading to exposure of higher trophic level predators. In addition to historical tailings releases, in recent years several accidental slurry releases have also occurred. These releases resulted in the discharge of heavy metals and cyanide directly into Gold Run Creek which drains into Whitewood Creek.

### Potential Receptors and Exposure Pathways

Receptors identified for this assessment are the same as for the SERA, and include aquatic receptors (aquatic plants, BMI and fish), amphibians (aquatic life stage), terrestrial receptors (terrestrial plants, soil and terrestrial invertebrates), and wildlife receptors (terrestrial insectivores, herbivores, carnivores, omnivores, aquatic insectivores, and piscivores). These receptors may be potentially exposed to chemical contamination via one or more exposure media (Figure 3-1), including surface water, sediment, sediment pore water, seeps, aquatic food items, surface soil, and terrestrial food items. However, not all exposure pathways are of equal concern and not all require detailed evaluation. The following identifies which pathway are of chief concern at this site and which were selected for quantitative evaluation.

#### *Aquatic Receptors*

- The main pathway of exposure for all aquatic receptors is direct contact with surface water. This pathway was evaluated quantitatively for fish, benthic invertebrates, periphyton, and amphibians.
- Direct contact with sediment and porewater is a potentially significant pathway for benthic macroinvertebrates. Data are available to allow an assessment of risks from

direct contact with sediment, and this pathway was evaluated quantitatively. However, no authentic samples of porewater are available from the site, so this pathway was not evaluated quantitatively. Other aquatic receptors have much less direct contact with sediment, and exposure to this medium is considered minor or negligible for fish, periphyton and amphibians.

- Ingestion of aquatic food web items is a pathway of potential concern for fish, benthic invertebrates, and amphibians. Likewise, incidental ingestion of sediment and water by these receptors might occur in some case. Quantitative evaluation of oral exposure of aquatic receptors is usually limited by lack of oral toxicity values for aquatic receptors, but sufficient data are available to support a screening-level evaluation of risks from ingestion of food web items and sediment by fish.

#### *Terrestrial Plants and Soil Invertebrates*

- The primary exposure pathway for both terrestrial plants and soil invertebrates is direct contact of with contaminated soils. This pathway was evaluated quantitatively for both receptors. For soil invertebrates, this evaluation includes both direct contact and soil ingestion.

#### *Wildlife Receptors*

- Wildlife receptors (birds, mammals) may be exposed to COPCs by ingestion of surface water (either from the stream or from seeps), and this pathway was evaluated quantitatively.
- Wildlife receptors (birds, mammals) may be exposed to COPCs by ingestion of food web items (either from the terrestrial environment and/or from the aquatic environment), and this pathway was evaluated quantitatively.
- Few wildlife receptors intentionally ingest soil or sediment, but many ingest these materials feeding, especially for soil- or sediment-dwelling prey items. This pathway can be important in some cases and was evaluated quantitatively.
- Direct contact (i.e., dermal exposure) of wildlife receptors to soils, sediments, surface water, and seeps may occur in some cases, but these exposures are judged to be minor in comparison to risks from ingestion exposure, and are not evaluated quantitatively.

- Inhalation exposure airborne dusts is possible for all terrestrial receptors. However, this pathway is generally very minor for non-volatile chemicals such as metals, and was not evaluated quantitatively.

### 3.3 Selection of Terrestrial Indicator Species

It is not feasible to evaluate exposures and risks for each avian and mammalian species potentially present within the site. For this reason, specific wildlife species are identified as surrogates (representative species) for the purpose of estimation of exposure and risk in the ERA. The surrogate species are wildlife species present within the Site area that are representative of other species with similar dietary preferences and feeding guilds. Selection criteria for wildlife surrogate species include trophic level, feeding habits, and the availability of life history information. The species identified as surrogate species at this site include:

**Masked shrew (*Sorex cinereus*).** The masked shrew represents mammalian insectivorous species that feed primarily on soil invertebrates.

**American robin (*Turdus migratorius*).** The American robin represents avian insectivorous passerine species that feed primarily on soil invertebrates.

**Deer mouse (*Peromyscus maniculatus*).** The deer mouse represents omnivorous mammalian species that feed primarily on plants, terrestrial insects, and soil invertebrates.

**Meadow Vole (*Microtis pennsylvanicus*).** The meadow vole represents herbivorous mammalian species that feed on terrestrial plants at the site.

**Cliff swallow (*Petrochelidon pyrchonota*).** The cliff swallow represents avian insectivorous species within the Whitewood Creek Site that feed on flying insects.

**Belted kingfisher (*Ceryle alcyon*).** The belted kingfisher represents piscivorous avian species that feed primarily on fish.

**Mink (*Mustela vison*).** The mink represents mammalian species that feed primarily on aquatic receptors (aquatic invertebrates and fish).

**Red fox (*Vulpes vulpes*).** The red fox represents mammalian species that feed on terrestrial vertebrates (small mammals).

**American kestrel (*Falco sparverius*).** The American kestrel represents avian species that feed on terrestrial vertebrates (small mammals).

**Great Horned Owl (*Bubo virginianus*).** The great horned owl represents avian species that feed on terrestrial vertebrates (small mammals).

**American Dipper (*Cinclus mexicanus*).** The American dipper represents avian species that feed primarily on aquatic invertebrates.

Exposure profiles are presented for each of these representative species in Appendix B.

### **3.4 Selection of Chemicals of Potential Concern**

Chemicals of Potential Concern (COPCs) are chemicals which exist in the environment at concentrations that might be of potential concern to ecological receptors, and which are derived, at least in part, from site-related sources.

The procedure used to select COPCs for this ERA is presented schematically in Figure 3-2. The selection procedure was similar for aquatic and wildlife receptors, except that risks from beneficial minerals such as sodium, potassium, iron, and calcium were not considered for wildlife receptors (since wildlife receptors have efficient homeostatic mechanisms to control the absorption of these minerals), but were considered for aquatic receptors.

The screening procedure was applied to surface water, sediment, and soil for each of the exposure scenarios of concern, as described in the site conceptual model. In brief, if there was no toxicity information to evaluate the potential effects of the chemical, the chemical was assigned to the "Qualitative COPC" category (Type 1). Chemicals that have an appropriate TRV but were detected in less than 5% of the samples from a medium (surface water, sediment, soil) were usually excluded from further consideration, since chemicals that are rarely detected at a site are not likely to be site-related. However, if the detection limit for a chemical was too high to expect detection of the chemical if it were present at a level of concern, the chemical was assigned to the "Qualitative COPC" category (Type 2). If a TRV was available for a chemical and the maximum detected value of the chemical (from anywhere on the site) was less than the TRV, it was concluded that the chemical does not occur at a level of potential concern and was not evaluated as a COPC. If the maximum detected value did exceed the TRV, then the chemical was evaluated quantitatively. It should be noted that this selection procedure is intended to be conservative; that is, the selection procedure is intended to eliminate only those

chemicals that are clearly not of potential ecological concern, and to carry forward those chemicals that might be of concern.

For surface water, the concentration values evaluated included measurements of dissolved metals and weak acid dissociable (WAD) cyanide for aquatic receptors and total recoverable metals and cyanide for wildlife receptors. The TRVs used to evaluate surface water and sediment are described in detail in Section 6.0. In brief, surface water risks to aquatic receptors were evaluated using the chronic Ambient Water Quality Criteria (AWQC) established by USEPA. In cases where the chronic AWQC is hardness dependent (as it is for most metals), a hardness of 200 mg/L was assumed, since most values measured at the site are at or above this level. Surface water risks to wildlife were evaluated using water benchmark values established by Sample et al. (1996). Sediment risks to aquatic receptors were evaluated using the sediment quality criteria established by McDonald et al. (2000) or by Ingersoll et al. (1996), and sediment/soil risks to wildlife from ingestion were evaluated using the dietary benchmarks established by Sample et al. (1996). Risks to terrestrial receptors from direct contact with soils were based on plant and soil organism toxicity benchmarks detailed in Section 7.0. The results of the COPC selection procedure are detailed in Appendix C and are summarized in Table 3-3.

### **3.5 Assessment Endpoints, Testable Hypotheses, and Measurement Endpoints**

Assessment endpoints are explicit statements of the characteristics of the ecological system that are to be protected. Assessment endpoints either are measured directly or are evaluated through indirect measures. Measurement endpoints represent quantifiable ecological characteristics that can be measured, interpreted, and related to the valued ecological components chosen as the assessment endpoints (USEPA, 1992; USEPA, 1997a).

The assessment endpoints and testable hypotheses for this site were initially developed as part of the data collection effort that was planned and performed to address the data needs identified by the SERA (ERT, 1999a), and were later modified or combined during the preparation of the risk assessment. The assessment endpoints were identified based on the habitat types present, the type of contaminants, and the potentially present species. For each assessment endpoint, there are testable hypotheses and proposed measurement endpoint(s) (measures of exposure and effects).

A summary of the assessment endpoints, testable hypotheses, and measurement endpoints is given in Table 3-4. The following sections provide a more detailed discussion of each.

### **3.4.1 Stream Viability and Function**

The structure and function of streams is important as they provide exclusive habitat for many species of plants and animals. Streams also process energy, organic matter, and nutrients. Biota utilizing the stream corridor rely extensively on the resources (i.e., forage) provided by the stream to support survival, growth, and reproduction. The BMI community of small streams plays a key role in stream ecosystem functions such as nutrient cycling and organic matter processing. Benthic organisms are also important food resources for other aquatic invertebrates and fish, as well as birds and mammals. The testable hypotheses and specific measurement endpoints for this assessment endpoint are provided in Table 3-4.

### **3.4.2 Riparian Floodplain Function and Viability**

The structure and function of the stream corridor is important as it provides a significant portion of the energy, organic matter, and nutrient inputs to the stream. Stream corridors usually provide high quality edge habitat for a variety of relatively sedentary birds, reptiles, amphibians, and mammals, which in turn rely on the stream to forage. The sedentary species that generally congregate near streams due to habitat and food availability are often preyed upon by more far-ranging species. The goal for this particular assessment endpoint is to identify if the riparian habitat on-site is significantly degraded relative to reference.

Specifically, the terrestrial rooted vascular plant community provides many functions including: erosion prevention (both water and wind), promotion of rainwater percolation, restriction of sheet water flow leading to reduced flooding potential, provision of nesting and cover habitat for wildlife, production of energy via photosynthesis, production of organic matter input (energy) to streams and soil systems, and reduction of surface wind velocity.

The soil invertebrate community plays a key role in nutrient cycling and organic matter processing. This community is also an important food resource for the terrestrial organisms including insectivorous small mammals and birds. The habitat within the on-site area has been modified substantially as a result of the direct deposition of waste materials containing contaminants and the indirect translocation of the contaminants by erosion processes. As a direct result, the soil structure has been modified through erosion and disruption of geomorphological processes. The high degree of habitat-specificity and the sedentary nature of soil invertebrates suggest a high potential for exposure. The testable hypotheses and specific measurement endpoints for this assessment endpoint are provided in Table 3-4.

### **3.4.3 Viability of Insectivorous Wildlife**

This assessment endpoint provides for the protection of insectivorous wildlife to insure that ingestion of contaminants in soil invertebrates, soil, and surface water does not have a negative impact on growth, survival, and reproductive success. Insectivorous birds and bats are important in the control of populations of emerging aquatic insects. Insectivores are important in nutrient processing and energy transfer between the aquatic and terrestrial environment, as well as within the terrestrial environment. The testable hypotheses and specific measurement endpoints for this assessment endpoint are provided in Table 3-4.

### **3.4.4 Viability of Herbivorous/Omnivorous Wildlife**

This assessment endpoint provides for the protection of herbivorous and omnivorous wildlife to insure that ingestion of contaminants in plants, terrestrial invertebrates, soil, and surface water does not have a negative impact on growth, survival, and reproductive success. Herbivorous and omnivorous birds and mammals are important in nutrient processing and energy transfer within the terrestrial environment. The testable hypotheses and specific measurement endpoints for this assessment endpoint are provided in Table 3-4.

### **3.4.5 Viability of Carnivorous Wildlife**

This assessment endpoint provides for the protection of carnivorous wildlife to insure that ingestion of contaminants in small mammals, soil, and surface water does not have a negative impact on growth, survival, and reproductive success. Avian carnivores are important in the control of rodents and other small mammals with high reproductive capacities. The SERA (ISSI, 1998) pointed to a possible risk to lower trophic level organisms (i.e. avian insectivores and small mammals) indicating the need to evaluate risks for higher level predators. The testable hypotheses and specific measurement endpoints for this assessment endpoint are provided in Table 3-4.

### **3.4.6 Viability of Aquatic Insectivorous Wildlife**

This assessment endpoint provides for the protection of aquatic insectivorous wildlife to insure that ingestion of contaminants in benthic invertebrates, sediment, and surface water does not have a negative impact on growth, survival, and reproductive success. Insectivorous birds and bats are important in the control of populations of emerging aquatic insects. Insectivores are important in nutrient processing and energy transfer between the aquatic and terrestrial

environment, as well as within the terrestrial environment. The testable hypotheses and specific measurement endpoints for this assessment endpoint are provided in Table 3-4.

#### **3.4.7 Viability of Aquatic Piscivorous Wildlife**

This assessment endpoint provides for the protection of piscivorous wildlife to insure that ingestion of contaminants in fish, sediment and surface water does not have a negative impact on growth, survival, and reproductive success. The testable hypotheses and specific measurement endpoints for this assessment endpoint are provided in Table 3-4.

#### **3.4.8 Viability of Amphibian Community**

This assessment endpoint provides for the protection of the amphibian community to insure that exposure to contaminants in surface water, sediment, soil, and food does not have a negative impact on growth, survival, and reproductive success. The diversity, density, and the reproductive success (i.e. embryonic mortality) of an amphibian community has been shown to be a sensitive indicator of environmental stress. The lack of amphibian data available for predictive exposure and toxicity reference value derivation in the SERA (ISSI, 1998) indicated the need to further evaluate this community in the baseline assessment. The testable hypotheses and specific measurement endpoints for this assessment endpoint are provided in Table 3-4.

## **4.0 INVESTIGATIONS CONDUCTED SINCE THE SERA**

The SERA identified a number of data gaps where additional information was needed to help improve the reliability and accuracy of the risk assessment. A summary of these data gaps and recommendations for data collection activities was provided previously in Table 3-2. Several field investigations, site-specific toxicity evaluations, and community surveys were conducted between 1998 and 2001 that provide data which help address these data gaps. A summary of each of these investigations is provided in the following sections.

### **4.1 USEPA ERT Field Investigations**

In February of 1999, the USEPA Environmental Response Team Center (USEPA/ERT) and USEPA Region 8 prepared a workplan which specified the data to be collected in response to the data gaps identified in the SERA and necessary for the completion of an evaluation of the baseline ecological risk assessment. The specific work plans for the aquatic and terrestrial field studies are contained in the February 1999 Quality Assurance Work Plan (QAWP) (ERT, 1999a).

In June 1999, a supplemental work plan was written to provide clarifications of the original work scope presented in the February 1999 QAWP. Modifications and/or amendments were made concerning the terrestrial sampling locations, soil sampling, terrestrial plant sampling, soil invertebrate sampling, small mammal trapping, toxicity evaluations, and amphibian survey (ERT, 1999b). This supplemental work plan also included an explicit outline of the Data Quality Objectives (DQOs) for the field investigations.

The aquatic and terrestrial field sampling were conducted in March and August 1999. A description of the study design and sampling locations for each field sampling event is provided below.

#### *USEPA ERT Aquatic Field Study*

The aquatic field sampling was completed during March 1999 with the initial results and evaluation of results provided in draft report issued in September 1999 (ERT, 1999c). The report was finalized in March 2001 (USEPA, 2001a).

The aquatic site included Whitewood Creek from Englewood, SD, north approximately twenty-nine miles to the terminal confluence with the Belle Fourche River. A portion of the Belle Fourche River immediately upstream and downstream of the Whitewood Creek confluence

and a site on Spearfish Creek were also evaluated. A total of 12 sampling locations were identified along Whitewood Creek, the Belle Fourche River, and Spearfish Creek. Sampling locations were established in streams impacted by the discharge of tailings from Homestake Gold Mine or to establish reference locations. These locations were situated in areas exhibiting similar habitat characteristics including substrate composition, riparian vegetation, topographic relief, channel morphology, flow velocity, watershed features, and land use.

The sample locations were assigned a number sequentially starting from the upstream extent of the site. Reference areas were denoted by the insertion of an "R" in the station ID (e.g., WWC-R-01). Sampling stations are presented in Figure 4-1.

- |          |                                                                                                                                                                                                                                          |
|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| WWC-R-01 | Whitewood Creek approximately 29 miles upstream of the confluence with the Belle Fourche River, Englewood, SD, upstream of the Homestake Gold Mine, 44 17.77N, 103 47.08W (Reference for stations WWC-02 and WWC-03).                    |
| WWC-02   | Whitewood Creek approximately 24 miles upstream of the confluence with the Belle Fourche River, Pluma, SD, upstream of the confluence with Gold Run Creek, 44 21.48N, 103 44.40W.                                                        |
| WWC-03   | Whitewood Creek approximately 24 miles upstream of the confluence with the Belle Fourche River, Pluma, SD, downstream of the confluence with Gold Run Creek, 44 21.62N, 103 44.33W.                                                      |
| WWC-04   | Whitewood Creek approximately 16.8 miles upstream of the confluence with the Belle Fourche River, at Crook City, downstream of bridge, downstream of the Homestake Gold Mine, 44 26.46N, 103 37.57W (e.g. beginning of former NPL site). |
| WWC-05   | Whitewood Creek approximately 14.4 miles upstream of the confluence with the Belle Fourche River, at Bighorn Road, upstream of bridge, downstream of the Homestake Gold Mine, 44 31.02N, 103 36.26W.                                     |
| WWC-06   | Whitewood Creek approximately 11.2 miles upstream of the confluence with the Belle Fourche River, Berger Seep, downstream of the Homestake Gold Mine; 44 33.03N, 103 32.89W.                                                             |

WWC-07	Whitewood Creek approximately 8 miles upstream of the confluence with the Belle Fourche River, at 194th Street, upstream of bridge, downstream of the Homestake Gold Mine; 44 35.30N, 103 31.72W.
WWC-08	Whitewood Creek approximately 1.2 miles upstream of the confluence with the Belle Fourche River (Siphon Area), downstream of the Homestake Gold Mine; 44 36.80N, 103 29.13W.
WWC-09	Whitewood Creek approximately 0.75 miles upstream of the confluence with the Belle Fourche River (Keiry Property), downstream of the Homestake Gold Mine; 44 38.10N, 103 27.14W.
BFR-R-10	Belle Fourche River approximately 1 mile upstream of the Whitewood Creek confluence; 44 40.13N, 103 29.20W (Reference for station BFR-11).
BFR-11	Belle Fourche River approximately 1 mile downstream of the Whitewood Creek confluence; 44 38.35N, 103 25.55W.
SPC-R-12	Spearfish Creek approximately 4 miles upstream of the confluence with the Redwater River; 44 35.50N, 103 52.98W (Reference for stations WWC-04 through WWC-09).

It is important to note that the March 1999 sampling location WWC-R-01 was subsequently identified as a former turnaround point for a rail line and consequently had elevated metals concentrations in soils. For the purposes of the baseline ERA, the March WWC-R-01 location is referred to as “WWC-R-01 M” to distinguish it from the August reference “WWC-R-01 A”. The August WWC-R-01 reference location was approximately 100 meters downstream of the March location. Table 4-1 provides a synopsis of the types of data that were collected during the aquatic field investigation.

#### *USEPA ERT Terrestrial Field Study*

The terrestrial field sampling began in March 1999 and was completed during August 1999 with preliminary results and evaluation provided in a draft February 2000 report. The final results were presented in a February 2001 report (USEPA, 2001b).

The terrestrial field site and sampling locations are the same as that identified for the aquatic study. However, stations WWC-02, WWC-03, WWC-04 and BFR-11 were not sampled for the terrestrial investigation. Station WWC-07 was chosen because of its large tailings deposits exposed at the surface and was selected to represent a soil matrix dominated by tailings material (USEPA, 2001a). A map of the sampling locations was presented previously in Figure 4-1. Table 4-2 summarizes the types of data that were collected during the terrestrial field investigation.

## **4.2 Seep Studies**

Groundwater movement through the tailings deposits in the Whitewood Creek valley enter the Creek at various seeps along its downstream course to the Belle Fourche River. In 1998, a survey of the existing seeps along Whitewood Creek and the Belle Fourche River was conducted. The location of each identified seep is presented in Figure 4-2. A total of 45 seeps were identified on Whitewood Creek and 7 on the Belle Fourche River.

In order to determine the potential hazard to aquatic life in Whitewood Creek posed by contaminants in seep water, ambient concentrations of contaminants in seep waters were tested to assess their biological affects on young fish (USGS, 2000). The purpose of this study was to determine if exposure of larval fathead minnow (*Pimephales promelas*) to water from various seeps in Whitewood Creek affects their survival (USGS, 2000). The fathead minnow was selected as the test species because it is a commonly tested warm water fish, and the lower Whitewood Creek where the test seeps were located is a relatively warm water habitat (USGS, 2000).

Five seeps (23R, 23L, 31L, 32L, and 33L) were selected from a total of 52 seeps identified in a previous study conducted by the USFWS and SDGFP. These seep locations are presented in Figure 4-3 (USGS, 2000 report Figure 1). The selection of the seeps was based on a combination of measurable flow, visual precipitate, seep draining tailings, and the potential risk to fish and wildlife resources. Water was collected at three locations for each seep; Whitewood Creek above the seep, at the seep, and Whitewood Creek below the seep in the mixing zone. Reference water was used as the control treatment and was a blended water that simulated Whitewood Creek water (hardness of 668 mg/L as CaCO<sub>3</sub>). The reference water was well water from Gavins Point National Fish Hatchery in Yankton, South Dakota, which was blended with deionized water.

A total of 16 water samples, 5 seeps with 3 sample locations per seep and the reference sample, were tested for acute toxicity (96 hour exposure) to larval stage fathead minnows. Test water

was renewed after 24, 48 and 72 hours of exposure. Fish survival and abnormal behavior were recorded and the end of each 24 hour exposure period. After the 96 hour exposure, fish were measured for total length and weight. Acute toxicity results for the fathead minnow from exposure to seep waters will be presented and discussed in further detail in Section 6.0.

### **4.3 Aquatic Community Evaluations**

In addition to the aquatic habitat evaluation performed by ERT during the March 1999 Aquatic Field Investigation, several other evaluations of fish, benthic, and periphyton communities are also available.

Knudsen (2001a, 2001b) performed field surveys of fish, benthic, and periphyton populations at five stations along Whitewood Creek. Surveys were conducted in the spring (June) and fall (September) of 1998, 1999, and 2000. One station was located 400 meters upstream of Gold Run Creek, and was used as a reference station. The other four stations were located at 600, 1300, 4200, and 6000 meters downstream of Gold Run Creek. The main purpose of these studies was to assess the consequences of an accidental slurry release that occurred in May, 1998.

Chadwick Ecological Consultants, Inc. (2001) performed habitat assessments and surveys of fish, benthic, and periphyton populations along Whitewood Creek and Spearfish Creek in 1999 and 2000. Four stations were studied on Whitewood Creek, all between the confluence with Gold Run Creek and the Belle Fourche River. The site of Spearfish Creek was about 6.5km above the Redwater River, and was sampled because it was considered to be a potential reference stream.

The results of these studies are described and are utilized in the weight of evidence evaluation presented in Section 6.0.

### **4.4 Terrestrial Community Evaluations**

In 1997, swallow nest boxes were placed at the Whitewood Creek Siphon (WWC-08) and the Kiery property (WWC-09) as well as a reference location on Bear Butte Creek in the Black Hills and the North Platte River near Casper, Wyoming (Custer, 1997). Each box was visited regularly during the nesting period and the number of eggs or young present were recorded. Samples of the eggs, carcasses, liver, and diet of the nestlings were collected and analyzed for arsenic content.

## 5.0 DATA EVALUATION AND USABILITY

Previous and current investigations and site monitoring of the Whitewood Creek Site were reviewed for the availability of reliable and relevant analytical and biological data that could be used in the baseline ERA. Because the purpose of the risk assessment is to evaluate potential hazards from current site conditions, only data from 1990 and later were employed.

Table 5-1 provides a summary of the available studies and the types of data provided. Sections 5.1 to 5.6 provide a more detailed description of the available data for surface water, sediment, sediment pore water, seeps, floodplain soils, and biological tissue, respectively. These data characterize the nature and extent of chemical contamination and biological effects for the Whitewood Creek Site. Analytical results for all media are provided electronically in Appendix D.

### 5.1 Surface Water

Surface water data at the Whitewood Creek Site are available from three sources: United States Geological Survey (USGS) gaging stations, South Dakota Department of Environment and Natural Resources (SDDENR) surface water quality monitoring (WQM) stations, and the USEPA ERT aquatic field investigation. Each of these sources is discussed briefly below.

***United States Geological Survey.*** Surface water data are available from two USGS gauging stations along Whitewood Creek.

06436180 - Whitewood Creek above Whitewood

06436198 - Whitewood Creek above Vale

Station 06436180 (Whitewood Creek above Whitewood) is reported to have moderate-to-high bed slopes with briskly running water and represents the upstream boundary conditions to the Whitewood Creek site (USEPA, 1989a). This portion of the creek also represents the downstream end of the cold water aquatic habitat (USEPA, 1989a). Station 06436198 (Whitewood Creek above Vale) is just above the confluence of Whitewood Creek and the Belle Fourche River. This portion of the creek is reported to represent the transition zone between the cool and warm water aquatic habitats (USEPA, 1989a). The location of these stations is provided on Figure 4-1.

Samples are collected four times per year; in May (peak snowmelt), Fall (low stream flow), Winter (before ice forms), and during a high precipitation event. Samples are integrated both

vertically and horizontally in the water column. Samples are analyzed for total recoverable and dissolved inorganics, and several stream and water quality parameters (i.e., flow, alkalinity, hardness, pH).

Samples are also analyzed for cyanide using a dissolved cyanide method. Until the mid-1980's, USGS had used USEPA Method 335.4 (*Determination of Total Cyanide by Semi-Automated Colorimetry EPA/600/R-93/100*) for total cyanide. During the mid-1980's, USGS began using USGS Lab method #I230285 for "dissolved" cyanide. This dissolved method appears to use the same acid extraction as that for total cyanide, but is performed on field filtered samples. Because the acid digestion extraction is the same as that for total cyanide, these dissolved results are representative of total cyanide.

Surface water data for these USGS gaging stations were obtained electronically from the USEPA Storage & Retrieval (STORET) database system on February 22, 2001. At the time of the download, electronic results were available for USGS stations through September 1999. Selected data collected through September 2000 were manually entered from the South Dakota Water Resource Reports for 2000 and 2001.

***South Dakota Department of Environment and Natural Resources.*** Six South SDDENR water quality monitoring stations are located on Whitewood Creek. These sampling stations are shown in Figure 4-1.

- 460686 - Whitewood Creek above Gold Run Creek
- 460122 - Whitewood Creek at Hwy 85 Bridge SW of Deadwood
- 460123 - Whitewood Creek  $\frac{3}{4}$  mile above Lead WWTF
- 460685 - Whitewood Creek at Deadwood
- 460684 - Whitewood Creek at Crook City
- 460682 - Whitewood Creek above the Belle Fourche River

Grab samples are collected four times per year; in Spring, Summer, Fall, and Winter. Samples are analyzed for total recoverable and dissolved inorganics, and several stream and water quality parameters (i.e., flow, alkalinity, hardness, pH). Samples are also analyzed for cyanide using both a total and weak acid dissociable (WAD) extraction. Collocated total and WAD cyanide data are available mostly in recent years (approximately 1998 to 2001), and the ratio of total cyanide to WAD cyanide typically ranges between 2 and 5.

Surface water data for these SDDENR WQM stations were obtained electronically from the USEPA Storage & Retrieval (STORET) database system on February 22, 2001. At the time of

the download, electronic results were available for SDDENR stations through May 1998. Data for total and WAD cyanide collected through December 2001 were manually entered from the hard copy analytical laboratory Form I sheets (as provided by Patrick Snyder, SDDENR).

It is important to note that the metal concentrations measured by SDDENR are usually lower than those reported by USGS. This difference in concentrations could be related to differences in sample collection methodologies (eg: grab sample vs. integrated sample).

**USEPA ERT.** During the aquatic field investigation conducted by ERT in March 1999, surface water was collected from 9 sampling stations in Whitewood Creek (WWC-R-01 to WWC-09), 2 stations in the Belle Fourche River (BFR-R-10 and BFR-11), and 1 station on Spearfish Creek (SPC-R-12). These locations were situated in areas exhibiting similar habitat characteristics including substrate composition, riparian vegetation, topographic relief, channel morphology, flow velocity, watershed features, and land use. The station locations were presented previously in Figure 4-1.

Grab samples were collected at half the maximum depth from the middle of the channel, with the exception of the Belle Fourche River locations. Due to depth and high flow rates in the Belle Fourche River, surface water samples were collected from the river bank.

Surface water samples were analyzed for target analyte list (TAL) metals by three methods. The results were reported as “total”, “filtered”, and “recoverable”. “Total” is equivalent to total recoverable and “filtered” is equivalent to dissolved. “Recoverable” samples are similar to the “filtered” samples (both are filtered through a 0.45 µm glass-fiber filter by a peristaltic pump), but recoverable samples were acidified prior to filtration whereas filtered samples were acidified after filtration. Unfiltered surface water samples from each station were also analyzed for total cyanide. Stream parameters and water quality measurements, which may potentially affect the speciation of metals, were also analyzed in the field at each sampling location.

## **5.2 Sediment**

Although several studies have investigated bottom sediments from Whitewood Creek and the Belle Fourche River, most of these reports evaluate sediments collected prior to 1990 (i.e.: USGS, 1990; Fox Consultants, 1984a). The aquatic field investigation conducted by ERT in March 1999 provides current information on bottom sediments in Whitewood Creek and the Belle Fourche River.

Sediment samples were collected from each of the ERT aquatic sampling stations from representative depositional areas. Several collocated sediment grab samples were collected using a hand trowel and homogenized prior to analysis. All samples were analyzed for TAL metals and total cyanide (ERT, 2001a).

At six locations (WWC-06, WWC-08, WWC-09, BFR-R-10, BFR-11, SPC-R-12) additional sediment samples were collected for simultaneously extracted metals (SEM) and acid volatile sulfides (AVS) analysis as per procedures utilized by the Environmental Monitoring and Assessment Program (EMAP) (USEPA 1993b; USEPA, 2001a). Due to the high gradient of the upstream locations, very few areas of deposition existed, hence the areas downstream with less gradient provided for possible sediment deposition and AVS formation. Five replicate cores were collected per sampling location. One of the replicates was analyzed for SEM/AVS and the remaining replicates were archived for possible future analysis. The SEM/AVS results will be discussed further when evaluating the bioavailability of COPCs in sediment.

### **5.3 Porewater**

Currently, there are no field-collected sediment pore water samples available for the Whitewood Creek site. Measurements of TAL metals are available for the sediment supernatant which was collected via centrifugation after completion of the ERT solid-phase sediment toxicity tests. However, these samples may not be entirely representative of pore water conditions *in situ*, and are used here mainly to help interpret the sediment toxicity results.

### **5.4 Seeps**

Groundwater movement through the tailings deposits in the Whitewood Creek valley enter the creek at various seeps along its downstream course to the Belle Fourche River (USGS, 2000). Seeps and shallow groundwater along Whitewood Creek and the Belle Fourche River have been studied by Hagler-Bailley (Hagler, 1998), the USGS (USGS, 2000), and USEPA ERT (USEPA, 2001b).

In April 1998, a survey of the existing seeps along Whitewood Creek and the Belle Fourche River was completed (Figure 4-2). A total of 45 seeps were identified on Whitewood Creek and 7 on the Belle Fourche River. At 33 seep locations, the pH, conductivity, and temperature were recorded; where possible, flow readings were also recorded.

The USGS selected five seeps (23R, 23L, 31L, 32L, and 33L) previously identified in the seep survey to conduct site-specific survival tests using larval fathead minnow (*Pimephales*

*promelas*). These selected seep locations were presented previously in Figure 4-3. The selection of the seeps was based on a combination of measurable flow, visual precipitate, seep draining tailings, and the potential risk to fish and wildlife resources. Water was collected from three locations for each seep; Whitewood Creek above the seep, at the seep, and Whitewood Creek below the seep in the mixing zone. Seep samples were analyzed for TAL metals and several water quality parameters.

Seep samples were also collected by ERT during the aquatic field investigation from along Whitewood Creek at four sampling stations (WWC-06 through WWC-09). For stations on Whitewood Creek, visible seeps were sampled. Samples were collected directly at the seep and analyzed for total recoverable TAL metals plus molybdenum and boron (USEPA, 2001b).

## **5.5 Soils**

Although several studies have investigated floodplain soils along Whitewood Creek and the Belle Fourche River, most of these reports evaluate soils collected prior to 1989 (i.e.: Fox Consultants, 1984a; USGS, 1988a,b). The baseline ERA has been restricted to soils data collected since 1990 to better characterize current site conditions.

During March and August 1999, ERT collected surficial soil (0 to 8 centimeters below ground surface) sites along Whitewood Creek (WWC-R-01, WWC-05 through WWC-09), the Belle Fourche River (BFR-R-10), and Spearfish Creek (SPC-R-12) coinciding with the vascular plant and small mammal collections during the terrestrial field investigations. In addition to the surface soil, samples of tailings material were also collected at WWC-07 and WWC-09. Individual grab samples were collected using a disposable plastic trowel or stainless steel trowel or shovel. Grab samples were placed into a plastic bucket and homogenized prior to analysis. All samples were analyzed for TAL metals and total cyanide analysis.

It is important to note that the samples collected during the March and August 1999 sampling events were not taken from the exact same location. The August samples were collocated with the small mammal and plant evaluations, rather than the previous corresponding March location. The March samples consisted of one replicate per location, were at least five replicates were collected in August.

## **5.6 Biological Tissues**

### **5.6.1 Benthic Macroinvertebrate Tissue**

Three studies are available which provide data on chemical concentrations in benthic invertebrates prior to 1989; Fox Consultants, Inc. (1984a) and USGS (1988c and 1988d). Because data used in the baseline ERA was limited to samples collected since 1990, these studies were excluded.

During the aquatic field investigation conducted by ERT, benthic macroinvertebrates were collected by hand from rocks removed from the stream bed and composited from all aquatic sampling locations. At five locations (WWC-R-01, WWC-02, WWC-03, WWC-04, WWC-05), benthic invertebrates were randomly placed into one of two sub-samples. The first sub-sample was designated as the “non-depurated” sample. The remaining sub-sample invertebrates were maintained alive for 24 hours to depurate their gut contents; this sub-sample was designated as the “depurated” sample. The number of individuals in each sub-sample and the total sample wet weight was documented. All samples were analyzed for TAL metals and percent moisture.

### **5.6.2 Fish Tissue**

Data on chemical concentrations in fish tissue are available from four studies; Fox Consultants, (1984a), Chadwick & Associates, Inc. (1990a), Chadwick & Associates, Inc. (1996), and USEPA (2001a). Of these studies only two collected fish after 1989, these studies will be used to evaluate risks in the baseline ERA.

***Chadwick Ecological Consultants, Inc. (1996).*** In 1996, fish were sampled from four stations on Whitewood Creek (WWC1 through WWC4); one station on the Belle Fourche River (BFR2) downstream of the confluence with Whitewood Creek; and one station on the Belle Fourche River (BFR1) upstream of the confluence with Whitewood Creek (Chadwick Associates, Inc. 1996). These stations are shown in Figure 4-1. Whole-body forage, rough, and game fish tissue sample results for five metals (arsenic, lead, mercury, selenium, and zinc) were reported in the 1996 review report (Chadwick Ecological Consultants, Inc. 1997).

***USEPA ERT.*** Forage fish were collected from Whitewood Creek (WWC-06, WWC-08), Spearfish Creek (SPC-R-12), and the Belle Fourche River (BFR-R-10, BFR-11) using seines. Information on fish taxonomy and length and weight measurements were recorded in the field. Because of the need for tissue analysis to evaluate the potential transfer of COPCs to piscivorous birds, whole fish were prepared for analysis. Three composite samples (of the same species, if

possible, and biomass) were collected from each location, with the exception of station WWC-08. This provided a total of 17 samples. Fish length and weight measurements and taxonomic identification were confirmed prior to shipment to the analytical laboratory. Fish tissues were analyzed for TAL metals and percent moisture.

### **5.6.3 Terrestrial Plant Tissue**

Plant tissue data are available from Fox Consultants, Inc. (1984a) and USEPA (2001b). For the purposes, of evaluating exposures to wildlife receptors from the ingestion of plants, tissue data was limited to samples collected by ERT in August 1999 as it is a better estimate of current exposures.

**USEPA ERT.** Vegetation was collected by hand at five soil sampling locations (WWC-R-01, WWC-05, WWC-06, WWC-08 and SPC-R-12) for residue analysis of TAL metals and percent moisture. The most abundant taxa (grasses), and/or taxa otherwise important in the food web (sweet clover), observed at these sampling locations were targeted for residue analysis. Five samples were collected from within each area and each sample consisted of several grab samples. The above ground portion of plants in the sampling area were collected by cutting the stems at the soil surface with a knife or shears. The plants were cut into 15cm lengths and packaged in sample containers. Prior to analysis, one sub-sample was rinsed to remove any loose soil particles and designated as “washed”, the other sub-sample was designated as “unwashed”.

A single sweet clover (*Melilotus* sp.) replicate was also collected from all locations and analyzed for TAL metals in leaves/flowers, stems, and whole-plant to determine if any translocation of metals within the plant existed.

### **5.6.4 Terrestrial Invertebrate (Grasshopper) Tissue**

In August 1999, ERT collected terrestrial macroinvertebrates (grasshoppers) with insect sweep nets at all plant sampling locations (WWC-R-01, WWC-05, WWC-06, WWC-08, and SPC-R-12). A mixture of species were collected from each location. One composite sample consisting of approximately twenty grasshoppers was collected at each location and analyzed for TAL metals and percent lipid content. These results are used to estimate exposures for terrestrial receptors resulting from the ingestion of food items.

### **5.6.5 Soil Invertebrate (Earthworm) Tissue**

Currently, there are no measurements of soil invertebrate tissue concentrations in field collected organisms. However, bioaccumulation of metals in tissues was evaluated in the laboratory by ERT (USEPA 2001b) as part of the 28 day soil toxicity test conducted in earthworms (*Eisenia foetida*).

Each soil toxicity test consisted of three replicates per sample location and a control. Each replicate contained 220 grams of soil dry weight and ten worms ranging in wet weight from 300 to 600 milligrams each. The organisms were fed throughout the duration of the exposure to allow survival and growth for the duration of the test. Following toxicity testing, the surviving earthworms were purged of gut contents for 24 hours and frozen for residue analysis of TAL metals. The bioaccumulation results for the earthworm 28 day test were used to estimate exposures and evaluate risks for terrestrial receptors from the ingestion of food items.

### **5.6.6 Small Mammal Tissue**

In August 1999, ERT conducted small mammal trapping and analyzed tissue samples to provide exposure data for carnivorous wildlife. A combination of traps were set in high grass or bushy areas and along edge habitat at stations WWC-R-01, WWC-05, WWC-06, WWC-08, and SPC-R-12. Species and sex determination, total weight, total tail and hind foot lengths, and notable physical conditions were recorded prior to analysis for TAL metals and percent lipids. Partial necropsies were performed to obtain kidney and liver weights. A tissue section was removed for histopathological analysis from the spleen, liver, and kidney of each small mammal. Metals concentrations in small mammal tissues were used to evaluate risks for terrestrial wildlife receptors from the ingestion of small mammals.

### **5.6.7 Bird Tissue**

Currently, only one study provides concentration data for metals in bird tissue. In 1997, swallow nest boxes were placed at the Whitewood Creek Siphon (WWC-08) and the Kiery property (WWC-09) as well as a reference location on Bear Butte Creek, South Dakota, and the North Platte River near Casper, Wyoming (Custer, 1997). Each box was visited regularly during the nesting period and the number of eggs or young present were recorded. Samples of the eggs, carcasses, liver, and diet of the nestlings were analyzed for arsenic content.

## 6.0 ASSESSMENT OF STREAM VIABILITY AND FUNCTION

This section presents an assessment of stream viability and function at the Whitewood Creek site. Streams are important because they provide exclusive habitat for many species of plants and animals. Streams also process energy, organic matter, and nutrients. Biota utilizing the stream corridor rely extensively on the resources provided by the stream to support survival, growth, and reproduction. The benthic macroinvertebrate (BMI) community of a stream plays a key role in ecosystem functions such as nutrient cycling and organic matter processing. Fish and BMI are also important food resources for both aquatic and terrestrial receptors.

### 6.1 Chemicals of Potential Concern for Aquatic Receptors

The procedure used to select chemicals of potential concern in surface water and sediment were presented in Section 3.4. The COPCs that were selected for quantitative evaluation are summarized below:

Quantitative COPCs for Aquatic Receptors	
Surface Water	Sediment
Aluminum, Copper, Cyanide, Lead, Selenium, Silver	Arsenic, Cadmium, Copper, Lead, Manganese, Mercury, Nickel, Zinc

### 6.2 Comparison of COPC Concentrations in Site Media to Toxicity Benchmarks

One way to characterize the potential risks to aquatic receptors from exposure to COPCs in surface water or sediment is the Hazard Quotient (HQ) approach. The HQ is defined as the ratio of the exposure point concentration to the appropriate toxicity benchmark:

$$HQ = \frac{\text{Concentration}}{\text{Benchmark}}$$

If the HQ is less than or equal to one, it is believed that no unacceptable effects will occur in the exposed aquatic population. If the value of HQ exceeds one, then unacceptable effects may occur, with the likelihood and/or severity of effects tending to increase as the value of the HQ becomes larger.

## 6.2.1 Surface Water Concentrations Compared to Toxicity Benchmarks

### *Surface Water Concentration Values*

For most metals and metalloids in surface water, the concentration value may be expressed either as total recoverable or as "dissolved" (that which passes through a fine pore filter). Because there is general consensus that toxicity to aquatic receptors is dominated by the level of dissolved metals (Prothro, 1993), all exposure and risk calculations for metals in this ERA are based on the estimates of dissolved concentration.

For cyanide, the situation is somewhat more complex. Cyanide may occur in water in a variety of forms, including free cyanide ( $\text{HCN}$  and  $\text{CN}^-$ ), simple cyanide salts, metalocyanide complexes, and as a variety of organic compounds (Callahan et al., 1979; USEPA, 1984). Toxicity from cyanide in water is likely due to free cyanide. However, reliable analytical methods are not currently available to quantify free cyanide, so results are generally reported as one of the following:

*Weak Acid Dissociable (WAD) cyanide.* This includes free cyanide and cyanide complexes that can be liberated by weak acids (acids with pH ranging from 4-6, such as acetic acid).

*Strong acid dissociable (SAD) cyanide.* This includes cyanide complexes liberated by the action of strong acids (such as sulfuric or hydrochloric acid). SAD cyanide complexes are typically stable and not a major threat to the environment.

*Total cyanide.* This includes all forms of cyanide, including free cyanide and both WAD and SAD cyanide complexes.

For the purposes of this risk assessment, WAD cyanide is used as the best available analytical estimate of the concentration of the toxicologically relevant form of cyanide. However, it should be understood that WAD cyanide levels are expected to overestimate free cyanide levels, and hence may overestimate risk of cyanide toxicity.

Because concentrations of COPCs in surface water can vary significantly over time and location, exposure is best characterized as a distribution of individual values at each sampling location, rather than as an average of values over time and/or over location. That is, an HQ value is calculated for each sample. In cases where the toxicity of a COPC is hardness-dependent, any sample where hardness was not reported was not included in this distribution.

### *HQ Values Based on Ambient Water Quality Criteria*

The USEPA (USEPA, 1999a, 2001c) has established acute and chronic Ambient Water Quality Criteria (AWQC) values for each of the COPCs selected for evaluation in surface water. The acute AWQC is intended to protect against short-term (48-96 hour) lethality, while the chronic AWQC is intended to protect against long-term effects on growth, reproduction, and survival. AWQC values are not species-specific, but are designed to protect 95% of the aquatic species for which toxicity data are available (USEPA, 1985).

For the COPCs at this site, many of the AWQC values are dependent on the hardness of the water, so the precise value of the acute and chronic AWQC that applies to a sample depends on the hardness of that sample. The equations used to calculate the acute and chronic AWQC values for dissolved metals are presented in Table 6-1. This table also lists the hardness ranges tested in the dataset used to derive the AWQC equations. Because extrapolation beyond these values is uncertain, the maximum tested hardness was used as a conservative value in calculating AWQC values for samples with higher hardness values.

Detailed risk calculations based on the default AWQCs are provided in Appendix E. The results are summarized graphically in Figures 6-1a to 6-1f. Note that the results in these figures are plotted on a log-scale, so large differences between HQ values are somewhat compressed. In each figure, the upper panel reflects risks of acute toxicity from short-term exposures, while the lower panel reflects risks of chronic effects on growth or reproduction due to longer-term exposure. The bar for each station reflects the variability in concentration (and hence risk) between different samples of surface water from the station. Inspection of these figures reveals the following main conclusions:

- Acute HQs for aluminum, copper, lead, selenium, and silver are below a level of concern at all sampling locations.
- Chronic HQs for copper, lead, and selenium are below a level of concern for a majority of samples at most Whitewood Creek stations downstream of Gold Run Creek. However, some HQ values greater than 1E+00 do occur, suggesting these chemicals may contribute an intermittent low-level stress on aquatic receptors.
- Acute and chronic HQs for WAD cyanide are largely above a level of concern at most stations on Whitewood Creek, and do not drop below a level of concern until many miles downstream of Gold Run Creek near the Siphon.

Evaluation of concentration data by comparison to AWQC values is useful in assessing risks to the aquatic community as a whole, but does not provide information on which species and lifestages may be most at risk. Figure 6-2 compares data on the distribution of WAD cyanide concentrations in Whitewood Creek to the range of species-mean toxicity values for fish and BMI derived from AWQC Documents (USEPA 1985, 1996b) as follows:

Acute TRV = Species or genus mean LC50 / 2

Chronic TRV = Species or genus mean chronic value

The species presented are those that occur in, or are similar to other species that occur in Whitewood Creek.

As seen in Figure 6-2, WAD cyanide concentrations are below a level of concern in the upstream (reference) segment of Whitewood Creek, but are often above a level of concern for both acute and chronic toxicity values at most stations downstream of the confluence with Gold Run Creek for most fish species, including both cold water (brook trout and rainbow trout) and warm water (bluegill) fish species. WAD cyanide concentrations are often in a range of chronic concern for *Daphnia*, but would not be expected to cause effects on most other invertebrates downstream of Gold Run Creek.

In interpreting Figure 6-1f and Figure 6-2, it is important to recall that AWQC values and species-specific toxicity values for cyanide are based on free cyanide, but the concentration estimates are based on WAD cyanide. Therefore, HQ values based on WAD cyanide may tend to overestimate the risks to aquatic receptors.

#### *HQ Values Based on Site-Specific Standards*

Site-specific surface water quality standards have been established for several chemicals for the reach of Whitewood Creek from the confluence of Gold Run Creek to the Interstate 90 bridge (SD Article 74:51:01:56). In brief, these standards are based on several site toxicity tests and are intended to be protective of a 90-day put-and-take stockable trout fishery. The site-specific standards for this reach are presented below.

<b>Chemical</b>	<b>30-day Average (ug/L)</b>
Copper (Total Recoverable)	80
Lead (Total Recoverable)	70
Silver (Total Recoverable)	20
Cyanide (WAD)	80

Detailed risk calculations based on the site-specific standards for copper, lead, silver, and cyanide are provided in Appendix F. The results are summarized graphically in Figures 6-3a to 6-3d. As seen, HQs based on the site-specific standards for copper, lead, and cyanide are all below a level of concern. For silver, HQ values based on the site-specific standard are below 1E+00 for all but one sample. These results indicate that toxicity from surface water to stockable trout species in Whitewood Creek is unlikely to occur. It is important to note, however, that these site-specific standards are not intended to be protective of younger and more sensitive life stages of trout and other aquatic receptors, and that compliance with the site-specific standards is not direct evidence that there are no risks to the aquatic community.

#### 6.2.2 Sediment Concentrations Compared to Toxicity Benchmarks

Benthic macroinvertebrates that spend some or most of their life cycle within the sediment substrate are exposed to COPCs through direct contact with sediment. In this risk assessment, potential risks for benthic macroinvertebrates from COPCs in sediment were evaluated by three separate approaches:

1. Calculation of HQs that compare sediment concentrations of COPCs to sediment toxicity benchmarks.
2. Calculation of a mean probable effect concentration ratio for each sediment sampling location to predict the incidence (probability) of observing toxicity in site sediments.
3. Comparison of Simultaneously Extractable Metals (SEM) concentrations to the level of Acid Volatile Sulfide (AVS) in sediment.

Each of these three approaches is summarized below.

### *Sediment Concentration Values*

Although concentrations of COPCs in sediment are usually not as time-variable as concentrations in surface water, concentrations do fluctuate as contaminated material is added or removed by surface water flow. In addition, there may be significant small scale variability in sediment concentrations at any specific sampling station. Therefore, exposure to sediments is usually best characterized as a distribution of individual values at a specific location. At this site, at present there is only one measurement of sediment concentration available per sampling location, so exposure was based on that single concentration value. These data are summarized in Table 6-2.

### *Sediment Toxicity Benchmarks*

The USEPA has not established National TRVs for total recoverable metals in sediment. Therefore, toxicity benchmarks for benthic invertebrates for exposure to COPCs in sediment were identified based on a review of sediment quality guidelines published in the literature. Several sets of sediment quality guidelines are available. The National Oceanic and Atmospheric Administration (NOAA) compiled a set of Effects Range Low (ERL) and Effects Range Median (ERM) levels for chemicals in sediment (Long and Morgan, 1990). The Ontario Ministry of Environment has identified a set of Severe Effects Threshold (SET) values (Persaud et al., 1993). MacDonald Environmental Sciences Ltd. (1994) expanded on the work of Long and Morgan (1990) and developed a set of guidelines including threshold effects levels (TELs) and probable effects levels (PELs). These sediment quality guidelines are derived based on data primarily from marine environments.

**Ingersoll et al. (1996)** compiled freshwater sediment toxicity data from nine different sites in the United States and identified a series of sediment effect concentrations (SECs) for a series of metals in sediment. The SECs are defined as the concentrations of individual contaminants in sediment below which toxicity is rarely observed and above which toxicity is frequently observed. The database was compiled to classify toxicity data for Great Lakes sediment samples. Ingersoll et al. (1996) derived five different SECs according to the methodology of Long and Morgan (1990), Persaud et al. (1993) and MacDonald Environmental Sciences Ltd. (MES) (1994). The SECs include an ERL, ERM, TEL, PEL, and no effect concentration (NEC). Ingersoll et al. (1996) calculated these freshwater ERL, ERM, TEL, and PEL values using the same procedures as NOAA and MES (1994).

**NOAA ERL and ERM Values.** The NOAA ERL represents the 10th percentile of values sorted in ascending order reported to be associated with an adverse effect. The NOAA ERM is the median value in the ranking. An ERL is defined by Long and Morgan (1990) and Long et al. (1995) as the concentration of a chemical in sediment below which adverse effects are rarely observed or predicted among sensitive species. An ERM is defined by Ingersoll et al. (1996) as the concentration of a chemical above, which effects are frequently or always observed or predicted among most species. The ERLs calculated by Ingersoll et al. (1996) use the 15th percentile.

**State of Florida TEL and PEL Values.** MES (1994) calculated TELs and PELs using an expanded database of Long and Morgan (1990). Freshwater data were excluded from the analyses. Sediment concentrations associated with an adverse effect were sorted in ascending order and an ERL (15th percentile) and ERM (50th percentile) were identified. The concentrations associated with no adverse effect were also sorted and a no effect range high (85th percentile) and no effect range median (50th percentile) were identified. The TEL is equal to the geometric mean of the ERL and no effect range median. The PEL is equal to the geometric mean of the ERM and the no effect range high. Although similar, the TEL and PEL values are lower than the ERL and ERM values. The values are lower because they are calculated using both "effect" and "no-effect" data; whereas, the ERL and ERM use only "effect" data. The NEC is the maximum concentration of a chemical in sediment that does not significantly adversely affect the particular response when compared to the control.

**Consensus-Based Sediment Quality Guidelines (SQGs).** In an effort to focus on agreement among the various sediment quality guidelines (previously discussed), MacDonald et al. (2000) issued consensus-based SQGs for 28 chemicals of concern. For each chemical of concern, a threshold effect concentration (TEC) and a probable effect concentration (PEC) were identified. The predictive reliability of these values was also evaluated. The criteria for establishing reliability of the consensus-based PECs was based on Long et al. (1998). This predictive ability analyses was focused on the ability of each SQG when applied alone to classify samples as either toxic or non-toxic. These criteria are intended to evaluate the narrative intent of the values. Sediment toxicity should be observed only rarely below the TEC and should be frequently observed above the PEC. Individual TECs were considered reliable if more than 75% of the sediment samples were correctly predicted to be non-toxic. Similarly, the individual PEC was considered reliable if greater than 75% of the sediment samples were correctly predicted to be toxic. Therefore the target levels of both false positives (samples incorrectly classified as toxic) and false negatives (samples incorrectly classified as non toxic) was

25% using the TEC and PEC. The SQGs were considered to be reliable only if a minimum of 20 samples were included in the predictive ability evaluation (MacDonald et al., 2000). The results of the reliability analyses are summarized in Table 6-3.

Because field-collected sediments contain a mixture of chemicals, a second analyses was completed to investigate whether the toxicity of a sediment could be predicted based on the average of the PEC ratios for the sediment, using only the PEC values that were found to be reliable. It was found that 92% of sediment samples with a mean PEC quotient  $> 1.0$  were toxic to one or more species of aquatic organisms. The relationship between the mean PEC quotient and incidence of toxicity is depicted in Figure 6-4. As seen, the mean PEC quotient was found to be highly correlated with incidence of toxicity ( $R^2 = 0.98$ ) (MacDonald et al., 2000).

For this ERA, the consensus-based SQG TEC and PEC values from MacDonald et al. (2000) are used as a range of toxicity benchmarks for sediments. For manganese, sediment toxicity benchmarks are the lowest and highest SEC values from Ingersoll et al. (1996). These values are summarized in Table 6-4. The lowest and highest benchmarks for each COPC in sediment are used to calculate a range of HQs. Even though none of the benchmarks are site-specific, if all HQ values were below 1E+00 based on the lowest benchmark, it would be concluded that risk of toxicity is low. Conversely, if a majority of HQ values based on the highest benchmark were substantially higher than 1E+00, it would be concluded that toxicity was likely.

#### *HQ Calculations for Exposure of Benthic Invertebrate to Sediments*

Detailed HQ calculations for sediment are provided in Appendix G and presented graphically in Figure 6-5. As noted previously, only one sample of sediment has been analyzed at each sampling station, so the results shown in the figure are based on only a single concentration value. Each of the series shown in the figure represents the range of alternative HQ estimates (low and high) based on uncertainty in the true threshold effect level in sediment. Inspection of Figure 6-5 yields the following conclusions:

- Predicted HQ values for sediment are generally below a level of concern for cadmium, manganese, nickel, and zinc.
- HQ values for copper, lead, and mercury exceed a level of concern based on the lowest TRV but are of minimal concern based on the highest TRV. Based on these comparisons, sediment toxicity from these chemicals is considered possible, but not certain.

- Predicted HQs from arsenic are substantially above 1E+00 at all non-reference segments of Whitewood Creek and the Belle Fourche River, based on both the lower and upper toxicity benchmarks. Based on this, arsenic is identified as a potential source of sediment toxicity. Note that HQ values for arsenic are also higher than 1E+00 immediately upstream of Gold Run Creek (WWC-02), indicating that there may be impacts to sediments in Whitewood Creek from sources upstream of the Homestake mine site. The source of this apparent contamination is not certain, but is probably due to releases from other historic mining operations in the area.

In considering this finding, it is important to recall that the sediment benchmarks are based on studies in which multiple contaminants were present, and therefore it is not certain that exceedence of a benchmark for a particular chemical will actually cause toxicity. In addition, there may be a wide variety of differences between Whitewood Creek sediments and the sediments used to establish the benchmarks, and these differences could influence the relative toxicity of chemicals in the sediments. Examples of differences include particle size, organic carbon content and pH. High organic content may diminish the apparent toxicity of bound chemicals and acidic sediments may be more toxic.

Because of these uncertainties, the HQ values for sediment based on the selected toxicity benchmarks should be viewed as part of the weight-of-evidence along with the results of site-specific sediment toxicity testing and the structure and function of the benthic invertebrate community.

#### *Mean Probable Effect Concentration Ratio*

As described earlier, MacDonald et al. (2000) found that the toxicity of sediment samples containing multiple chemicals could be reliably predicted from the mean probable effect concentration (PEC) quotient (i.e., the average HQ for each metal for which a reliable PEC was available to serve as the TRV). The equation recommended by MacDonald et al. (2000) was:

$$\text{Incidence of Toxicity (\%)} = 101.48 \cdot (1 - 0.36^x) \text{ where } x = \text{mean PEC ratio}$$

The calculated mean PEC values for sediment samples at this site, along with the predicted incidence of toxicity from the sediment, are summarized below:

<b>Mean PEC Quotient and Predicted Incidence of Sediment Toxicity</b>		
<b>Station</b>	<b>Mean PEC Quotient</b>	<b>Predicted Incidence of Toxicity</b>
WWC-R-01	0.1	13%
WWC-02	1.3	73%
WWC-03	2.7	95%
WWC-04	3.0	96%
WWC-05	5.3	100%
WWC-06	5.6	100%
WWC-07	2.8	95%
WWC-08	3.6	98%
WWC-09	2.7	94%
BFR-R-10	0.3	23%
BFR-11	6.3	100%
SPC-R-12	0.1	10%

McDonald et al. (2000) identified a mean PEC quotient of 0.5 as the threshold value for identifying toxic sediments. As seen above, at this site the mean PEC quotients exceed a value of 0.5 at all site locations, but are below a value of 0.5 at all reference locations. This suggests that sediments in Whitewood Creek and the Belle Fourche may be toxic to benthic organisms. However, as discussed above, because of potential uncertainties in this approach, mean PEC values above a value of 0.5 should be viewed as part of the weight-of-evidence along with the results of site-specific sediment toxicity testing and direct observations on the structure and function of the benthic invertebrate community.

#### *Benthic Toxicity Predictions Based on SEM/AVS*

A potential limitation to the approach of predicting risks for benthic organisms based on the concentration of metals in sediments is that not all of the metals in sediment particles may be chemically available for dissolution into the sediment porewater. Studies by a number of researchers have found that the tendency of metals in sediment to dissolve into the porewater is determined in large part by the amount of sulfide present in the sediment (Hansen et al. 1996, Ankley 1996, Ankley et al. 1996). This is because divalent cations of heavy metals such as cadmium, copper, lead, zinc, nickel, and mercury form highly insoluble complexes with sulfides. Thus, if the sediment contains sufficient sulfide to complex the metals, then dissolution into pore

water and resultant toxicity to benthic organisms is not expected (Hansen et al. 1996, Ankley 1996, Ankley et al. 1996).

Based on these considerations, one way to evaluate the risk to benthic organisms from metals in sediments is to measure the amount of acid-extractable cadmium, copper, lead, zinc, nickel, and mercury (these are referred to as Simultaneously Extractable Metals, or SEM) and compare this to the level of Acid Volatile Sulfide (AVS). If the measured level of SEM (umol/g) is the same or less than AVS (umol/g), then it is expected that porewater concentrations of metals will be low and that toxicity to benthic organisms will not be of concern. If the concentration of SEM exceeds the concentration of AVS, then toxicity may occur. However, there are other materials in sediment (e.g., organic carbon) which also tend to bind metals (Mahony et al. 1996, Hansen et al. 1996), so an exceedence of AVS by SEM is not proof that toxicity will definitely occur, especially if the exceedence is fairly small (e.g., less than about 5 umol/g).

During the aquatic field sampling in March 1999, ERT collected bulk surficial sediment samples from depositional areas on Whitewood Creek, the Belle Fourche River, and Spearfish Creek. Each sample was analyzed for total metals, SEM and AVS. The results are summarized in Table 6-5.

As seen, at most locations on Whitewood Creek the level of SEM is smaller than AVS, indicating that there is an excess of sulfide in the sediment and that toxicity is not expected. Small excesses (less than 1 umol/g) of SEM over AVS occurred at stations WWC-08, WWC-09, and BFR-11. This excess is sufficiently small such that other binding agents (e.g., organic carbon) may attenuate exposures from any metals that may leach into porewater.

A potential limitation to the SEM-AVS approach is that most AVS present in sediments is produced by anaerobic microorganisms, and that the level of AVS may vary as a function of the amount of oxygen that penetrates the sediment. Thus, it is not appropriate to extrapolate SEM/AVS data measured in anoxic depositional area sediments to sediments from oxygenated riffles. Likewise, if an anaerobic sediment were to become exposed to the air as a consequence of a drop in water level, metals which were bound in the form of AVS might become liberated and could result in a pulsed release of soluble metals when the sediment became re-submerged. Thus, an analysis of sediment hazard based on the difference between SEM and AVS should include the understanding that the measured values may apply only to a limited location and might change over time. Further, because available results for the Whitewood Creek site provide data for only one point in time, the data may not reflect the maximum difference between SEM and AVS.

### 6.2.3 Screening-Level Risks to Fish from Oral Exposure

Aquatic receptors (fish, benthic macroinvertebrates) may be exposed to COPCs in Whitewood Creek not only through direct contact with surface water, but also by ingestion of contaminants in sediment and food items. In general, evaluation of the risk to aquatic receptors from oral exposure is difficult because of limited availability of oral toxicity benchmarks. However, a screening level assessment of risk was performed for fish based on a set of TRVs (NOAEL and LOAEL) developed for another site (Clark Fork River) in USEPA Region 8 (USEPA, 2001d).

For the purposes of the screening evaluation, it was assumed that 100% of the trout diet is composed of benthic organisms. The concentration values of COPCs in benthic organisms (caddisfly larvae), the screening-level oral TRVs, and the resulting HQ values are shown in Table 6-6. As seen, the HQ values do not exceed a value of 1E+00 for cadmium, copper, lead, or zinc, but do occasionally exceed a value of 1E+00 for arsenic. These results suggest that ingestion of arsenic in food web items might be of concern to fish. However, there are several uncertainties in this conclusion. First, the calculations are based on only one composite sample of benthic organisms per station, so concentration values averaged over time and space might tend to be either higher or lower. Second, arsenic in most aquatic organisms tends to occur mainly as a non-toxic organic form. If the same is true for benthic macroinvertebrates, then the risks to fish may be lower than predicted. Third, all of the exceedences except one are for the NOAEL-based but not the LOAEL-based TRV. This suggests that if any effects occur, the results are likely to be minimal.

#### *Predicted Risks from Sediment Ingestion*

It is not believed that fish intentionally swallow inorganic sediments, but a few reports were located which indicate that sand or small stones are occasionally found in the stomach content of trout (Papageorgiou et al., 1984) and suckers (Carl 1936, Macaphee 1960). Even though the amount of inorganic sediment ingested may be small, the concentration of metals in sediments is usually substantially higher than the concentration in benthic organisms. To perform a screening level evaluation of risks to fish from incidental ingestion of sediment, the intake of sediment was assumed to be 5% of the dietary intake. This assumption is similar to values which have been suggested for trout (2%) and suckers (5%-10%) (Skaar, 1998). The TRVs used were the same as described above for ingestion of aquatic food items. The results are shown in Table 6-7. As seen, HQ values do not exceed a value of 1E+00 for any sediment sample at any station. This indicates that direct ingestion of sediment by fish is not likely to be of concern.

#### 6.2.4 Comparison of COPCs in Fish Tissue to Toxicity Benchmarks

Another way to estimate risks to fish is to compare the tissue level of COPCs observed in fish from the site to tissue concentrations that occur in fish with and without evidence of adverse effects. This approach has the advantage that it integrates exposures over all sources (surface water, sediment, food web), and accounts for any site-specific factors that might increase or decrease exposure compared to laboratory conditions.

##### *Fish Tissue Data*

Concentrations of COPCs in fish tissue are available from two studies. CEC et al. (1997) collected samples of forage, rough, and game fish from four stations along Whitewood Creek and two locations on the Belle Fourche River, and analyzed whole body samples for arsenic, lead, selenium, mercury and zinc. USEPA (2001a) collected three composite samples of game, rough, and forage fish from three locations along Whitewood Creek, two locations on the Belle Fourche River, and one location on Spearfish Creek, and analyzed the whole body samples for the full suite of TAL metals.

##### *Tissue Concentrations Associated with Adverse Effects to Fish*

Jarvinen et al. (1999) provide a compilation of studies that identify effect levels and no-effect levels of organic and inorganic chemicals, expressed in terms of fish tissue concentrations. These data are summarized in Table 6-8. For this risk assessment, the tissue-based toxicity benchmark (also referred to as the maximum acceptable tissue concentration, or MATC) was defined as the highest residue reported to be associated with no adverse effects (NOAEL) below the lowest reported residue that is reported to cause an adverse effect (LOAEL). If the only values available report adverse effects, then the LOAEL was used and divided by 2 to approximate a NOAEL. No tissue data for fish were located for manganese or nickel, so these chemicals were not evaluated by this approach.

##### *HQ Values for Fish Based on Fish Tissue COPC Levels*

Table 6-9 summarizes the fish tissue concentration data, the fish tissue MATC values, and the resulting HQ values for fish. Inspection of this table shows that all HQ values are consistently above 1E+00 for mercury and zinc. Note, however, that HQ values tend to be elevated for mercury and zinc at the reference locations (BFR1, BFR-10, SPC-12) as well as the site stations, suggesting the MATC values for these chemicals may be somewhat too low. There are two cases where the HQ based on arsenic is greater than 1E+00, both in the upper reaches of

Whitewood Creek (WWC1, WWC2). This suggests that arsenic might be of concern to some individual fish but probably not all fish (the average HQ for arsenic for all fish excluding reference locations is 6E-01). However, the data are too limited and the values too variable to draw a firm conclusion.

### 6.3 Site-Specific Sediment Toxicity Tests

One way to help reduce the uncertainty associated with HQ values based on sediment benchmark values is to perform direct toxicity testing using sediment samples collected at the Whitewood Creek Site. Such tests were performed by ERT (USEPA, 2001a), who conducted a 10-day chronic survival and growth toxicity test using the amphipod (*Hyalella azteca*) in accord with standard protocols. Test sediment samples were collected from 9 sampling stations at Whitewood Creek (WWC-R-01 through WWC-09), two stations on the Belle Fourche River (BFR-R-10 and BFR-11), and the Spearfish Creek reference (SPC-R-12). At each sampling station, the sediment toxicity test consisted of eight replicates using 100% site sediment (without dilution). The detailed results are presented in Appendix D of the ERT aquatic field sampling report (USEPA, 2001a), and are summarized in the upper portion of Table 6-10. As seen, statistically significant decreases in survival were noted for organisms exposed to sediments from stations WWC-05 and WWC-06, but not other stations<sup>1</sup>.

In order to identify the likely cause of the observed mortality at these two stations, concentrations measured in porewater were compared to acute AWQC and amphipod-specific<sup>2</sup> toxicity values. Results are shown in Figure 6-6. As seen, concentrations of arsenic exceeded both the acute AWQC and the acute amphipod-specific TRVs for samples from WWC-05 and WWC-06, suggesting that arsenic may have contributed to the mortality. However, arsenic concentrations also exceeded acute criteria at WWC-03 and BFR-11, but no mortality was seen at these locations. Cadmium exceeded the acute AWQC value at WWC-05 and WWC-06, but the amphipod-specific TRVs were not exceeded at either location. These results suggest that cadmium is unlikely to have contributed to the mortality in *H. azteca*. Lead, copper and zinc exceeded the acute criteria at WWC-03, but no mortality was observed at those locations. Ammonia exceeded the amphipod-specific TRV at both WWC-05 and WWC-06, suggesting that

---

<sup>1</sup> Survival of amphipods in one replicate of the Spearfish Creek sample (SPC-R-12) was 0%. The investigators report this as an anomaly compared to other sample replicates where average survival was 87.1%. The 0% survival in this anomalous replicate was attributed to two possible causes: 1) organisms were not added to the test chamber, or 2) the test chamber was contaminated. This result was excluded in the data analyses for SPC-R-12.

<sup>2</sup> Amphipod-specific TRVs were defined as the *Hyalella* sp. (or *Gammarus* sp. if *Hyalella* sp. data were absent) LC50 value divided by 2.

it may have contributed to the effect, but ammonia was also above the TRV at WWC-02, BFR-11 and SPC-R-12, without associated mortality.

In order to further evaluate these data, a regression analysis was performed to determine the degree and the direction of correlation between the observed mortality rate in the exposed organisms and the concentration of chemicals in the bulk sediment and in the pore water derived from the toxicity tests (these concentrations in bulk sediment and sediment pore water are shown in the middle and lower panels of Table 6-10). A potentially significant contributor was identified by a statistically significant ( $p < 0.05$ ) negative correlation ( $R < -0.6$ ) (i.e., as the concentration of the chemical goes up, survival and/or growth goes down). The results are shown in Table 6-11.

As seen, an association was observed for mercury in sediment and for arsenic and cadmium in porewater. These results suggest that one or more of these metals might be responsible for the increased mortality in *Hyalella*. However, there was also a statistically significant correlation between decreases in *Hyalella* survival and growth and the concentration of unionized ammonia measured in the test chambers at the start of the sediment testing. At the pH of the test water, the acute AWQC for total ammonia is about 3-4 mg/L and the acute TRV for *Hyalella* is about 1 mg/L, while the concentrations of total ammonia measured for WWC-05 and WWC-06 on day zero were 16.2 and 3.2 mg/L, respectively. Thus, the levels of ammonia were high enough in these samples that ammonia may have contributed to the toxicity. On the other hand, total ammonia was at a concentration of 3.1 mg/L in the water derived from the Spearfish Creek sample, but no excess mortality occurred in this sample, suggesting that ammonia alone may not have caused the effect (at least in WWC-06). The source of the ammonia in these samples is not known, but is not suspected to be related to mine wastes.

In summary, the results of the sediment toxicity test suggest that arsenic, cadmium, and/or mercury levels in sediment or porewater might increase the risk of acute mortality in exposed benthic organisms, but this conclusion is limited by the potential confounding effects of elevated levels of ammonia in the porewater. In addition, the porewater collected during laboratory-based sediment toxicity testing may not accurately reflect metal concentrations in pore water *in situ*.

#### **6.4 Assessment of Seep Water Toxicity**

Water that enters Whitewood Creek from groundwater seeps was investigated to determine if this water might be a significant source of dissolved COPCs in the stream and might be of concern to aquatic receptors. Three separate approaches for evaluating this potential concern are described below.

#### 6.4.1 Comparison of Seep Water Concentrations to AWQC Values

Although it is highly unlikely that aquatic receptors would be found directly in seep water, the potential for impacts of seep water to the creek may be screened by comparing the concentrations of chemicals in seep water to corresponding AWQC values. If the concentration in seep water does not exceed the AWQC, it is probable the seep water is not of concern for that chemical. If the concentration of a chemical in seep water exceeds the AWQC, there is a possibility the seep water could be of concern, but the impact (if any) would depend on the rate and degree of mixing of the seep water with the stream.

USGS (2000) collected seep water samples from five Whitewood Creek seeps (23R, 23L, 31L, 32L, and 33L) and one reference location to evaluate toxicity to larval fathead minnow (*Pimephales promelas*). Likewise, ERT (USEPA 2001a) collected seep water from four stations along Whitewood Creek (WWC-06, WWC-07, WWC-08, and WWC-09). The concentration values detected in these seeps and a comparison of those values with acute AWQC values are shown in Table 6-12a (data of USGS 2000) and in Table 6-12b (data of ERT). As seen, most chemicals are below a level of concern even in the undiluted seep water. However, arsenic levels in seep water are often above the acute and/or chronic AWQC value (Table 6-12a and Table 6-12b), and aluminum and lead are above the chronic AWQC value in two locations (Table 6-12b).

It should be noted that these results are based on seep water samples collected at only one or two points in time. Hence, the data may not be representative of the full range in seasonal variability in seep water concentrations, and may not reflect the maximum seep water concentrations which could occur.

#### 6.4.2 Comparison of Upstream and Downstream Concentrations

A second way to evaluate the impacts of seeps is to compare the concentration of metals in surface water at locations upstream of the seep with a downstream location that includes the mixing zone from the seep. Data of this type were collected by USGS (2000) at five different seeps. These data are summarized in Table 6-13. Shaded cells in the table indicate cases where the concentration downstream of the seep is more than 50% higher than in the corresponding upstream location. As seen, there are a number of cases where the downstream locations appear to be elevated compared to the upstream location. However, it is also true that none of the elevations result in an exceedence of the acute or chronic AWQC values. These data suggest that seeps may be contributing to the metals load in the river, but are not likely to be a source of significant toxicity.

### 6.4.3 Site-Specific Acute Toxicity to the Fathead Minnow

A third way to evaluate the potential risks from seep water is to test the toxicity of the water directly. A study of this type was performed by USGS (2000) at five locations along Whitewood Creek. Larval fathead minnows were placed in test chambers containing water collected from three locations (upstream, seep water, and downstream) at each of the five sampling stations, and survival, length, and weight were recorded at 24, 48, 72 and 96 hours of exposure. The survival results are presented in Table 6-14.

As seen, there was a slight reduction in survival in some seep waters (23R, 31L, 33L) and some mixing zone water (23R, 33L) compared to the upstream reference water, but these changes are sufficiently small that the effects may be random rather than treatment-related. These data suggest that most seep waters and the water downstream of the seeps is not likely to be significantly toxic to fathead minnows. However, it is important to note that the fathead minnow is not the most sensitive freshwater organism with regard to arsenic toxicity, and that this test does not establish that there is no potential hazard from seep water.

#### *Summary and Conclusions Regarding Seep Water Toxicity*

In summary, the following data are available to assess the potential hazard from seep water:

- Some metals concentrations in seep water are up to an order of magnitude more concentrated than water in Whitewood Creek. Influx of seep water often leads to an observable increase in metals concentration in the surface water downstream of the seep.
- Concentrations of arsenic in undiluted seep water exceed the acute and/or chronic AWQC for arsenic at several different seeps. However, concentrations of arsenic in the stream downstream of the seeps do not exceed a level of concern.
- The site-specific seep water samples and samples from the stream downstream of the seeps are not acutely toxic to the fathead minnow after 96 hours of exposure in laboratory testing (USGS, 2000).

Taken together, these data indicate that seep water is a source of increased loading to the stream, but provide little evidence to conclude that seeps contribute any significant risk of toxicity to aquatic receptors in Whitewood Creek. However, it should be noted that concentrations of metals in seep water might vary over time, and that the highest levels in seep water may not have been measured in these studies.

## **6.5 Comparison of the Aquatic Communities to Reference Communities**

Effects of chemical stressors on an ecosystem can sometimes be evaluated by direct observation of the density and diversity of species present in the ecosystem. At this site, observations on the aquatic community are available from a number of studies. These are summarized in Table 6-15. Studies performed prior to 1985 (Herrick 1982, Fox Consultants 1984a) demonstrated that populations of fish and benthic macroinvertebrates in Whitewood Creek were visibly impaired. This was attributed to a combination of chemical stresses due to release of mine process water and physical stresses (mainly high temperature during the summer). Because conditions in the river changed significantly in 1985 when the mine wastewater treatment system came on line, these studies are not considered to be relevant to current site conditions and are not considered further.

Studies performed between 1990 and 2001 have all demonstrated that there are relatively diverse and abundant communities of fish, benthic macroinvertebrates, and periphyton present in Whitewood Creek (Chadwick and Associates, Inc., 1990a, 1990b; Chadwick Ecological Consultants, Inc., 1997, 2000; Knudson 2000, 2001a, 2001b; USEPA 2001a). These studies support the conclusion that, in the absence of an accidental release or spill from the mine (e.g., see Knudson 200, 2001a, 2001b for an assessment of an accidental release that occurred in 1998), impacts of the mine, if any, on Whitewood Creek are not severe. However, it is important to recognize that the observation that aquatic species are present in Whitewood Creek is not equal to proof that residual mine wastes have no impact on the aquatic communities. This is because the number and identity of individuals and species that are present at any particular location in the creek depends on a very large number of factors, and a judgement whether there is a mining-related impact requires a good quantitative understanding of what would have been expected at the site absent any mine-related chemical stressors. This information is usually obtained by seeking an appropriate "reference" area, and comparing the observations from the site with the reference area. While this approach has a number of merits, it is sometimes difficult to find a reference location that is well-matched to the test location with regard to all (or even any) of the key determinants of population density and diversity. Thus, direct population studies should always be viewed as one element in the weight of evidence evaluation rather than a direct method for deducing presence or absence of site-related effects.

Presented below are more detailed reviews of those studies which provide data that allow a comparison of population demographics in Whitewood Creek with a reference site.

### 6.5.1 Fish Communities

*Chadwick (2001)*

Chadwick Ecological Consultants, Inc. (2001) used electrofishing to collect data on the diversity and density of fish populations present in September, 2000, at four stations in Whitewood Creek (all located downstream of Gold Run Creek), and compared those to observations at a reference location suggested by USEPA on Spearfish Creek.

Diversity. A total of nine fish species were observed in Whitewood Creek. In the upper portion of the stream, this included the longnose dace, white and mountain sucker, and brown trout. In the lower portion of the stream, several additional species were noted, including the sand shiner, fathead minnow, flathead chub, creek chub, and stonecat. At any one station, a total of 3-6 species were observed, compared to 4 species observed in the reference location (longnose dace, white sucker, brown trout, and brook stickleback). In Whitewood Creek, the longnose dace was the most abundant species, accounting for more than 90% of the individuals in the three upstream stations. In contrast, the brown trout was the most common species in the reference stream.

Density. The density (number of fish per hectare) in the three upstream stations in Whitewood Creek (16,000/ha to 28,000/ha) was higher than that seen in the reference station (3,900/ha). This was due mainly to the high density of longnose dace in the upper portion of Whitewood Creek. The biomass of fish in the upper reaches of Whitewood Creek (36-88 kg/ha) was somewhat lower than for the reference area (94 kg/ha).

Age Structure. Analysis of the length distribution of brown trout in Whitewood Creek indicated that multiple year classes were present, and that natural reproduction is probably occurring. The same was true of the reference stream.

Habitat Quality. A number of measures of habitat quality were collected at each sampling station. Whitewood Creek was generally similar in depth (0.3-1.3 feet) to Spearfish Creek (0.8 feet), but tended to be somewhat narrower, especially in the upper reaches (15-23 feet) than the reference stream (30-38 feet). Eroding banks were common in Whitewood Creek, but were absent in Spearfish Creek. Overall, the habitat rating for Whitewood Creek ranged from marginal to sub-optimal, while the rating for Spearfish creek was optimal.

Based on these findings, the author concluded that Spearfish Creek was not a good reference stream for use in comparisons to Whitewood Creek. Thus, while the data from this study provide a clear indication that a self-reproducing community of fish is present in Whitewood Creek, it is not possible to draw inferences as to whether mine-related contaminants are causing an impact in the stream.

*Knudson (2000, 2001a, 2001b)*

Knudson (2000, 2001a, 2001b) performed a series of aquatic population surveys at five stations on Whitewood Creek, one of which was 400 m above the confluence with Gold Run Creek. This station (designated WC-1) was used as a reference station. Fish were collected by repeated electrofishing passes. These studies were part of an investigation performed mainly to assess the impacts of a mining process release that occurred in May, 1998. The studies revealed that there was a clear impact of the release on the fish community in the summer of 1998, but that partial recovery was apparent by 1999 and near complete recovery had occurred by 2000. Thus, the fish survey data collected in June and September of 2000 are the judged to be most meaningful basis for an upstream-downstream comparison in Whitewood Creek. These data are summarized below.

Diversity. The most common species observed at the four downstream stations on Whitewood Creek in 2000 included brown trout, brook trout, longnose dace, and mountain sucker. These species were also the most common in the reference station.

Density. The density of fish (number per hectare) and the biomass (kg/ha) are summarized in Figure 6-7. Brown trout tended to be dominant in terms of both number and biomass. As seen, within a station, the density and biomass both varied between the samples collected in June and September, with the values in September tending to be higher. Within a sampling event (June or September), the density tended to be lower in the three downstream stations than in the reference location, while biomass did not show a consistent pattern of difference.

Condition. Condition factors (an index of the relation between length and weight) for brown trout and brook trout longer than 150 mm tended to be close to or slightly above 1.0 at all stations, with the downstream stations (especially WC-2) being slightly higher than the reference station (WC-1).

Age Structure. Analysis of the length distribution of brown trout population indicated that young of the year were present at all stations, indicating that natural reproduction is occurring.

Based on these data, Knudson (2001a, 2001b) concluded that the consistently higher condition factors and larger average size of brown trout (stratified by age group) at stations downstream of Gold Run Creek indicated that productivity (growth) was greater below Gold Run Creek than above Gold Run Creek. These findings support the conclusion that, absent the impacts of an accidental release, the populations of fish in Whitewood Creek are not significantly impacted by mining-related releases at locations below Gold Run Creek.

#### 6.5.2 Benthic Macroinvertebrate Communities

##### *USEPA (2001a)*

A benthic macroinvertebrate survey was completed by USEPA in March of 1999 at all aquatic sampling locations (except WWC-07) as one measure of stream function and viability (USEPA, 2001a). Rapid Bioassessment Protocols (RBP) were used to identify and evaluate the quality of habitat and the structure and function of the benthic invertebrate community (USEPA 1989c, 1990b, 1997b). Sampling locations were situated in areas that were judged to be typical and were likely to yield representative specimens of benthic macroinvertebrates. Three reference stations were established for comparisons, as follows:

Reference WWC-R-01. Serves as a reference for WWC-02 and WWC-03, since the substrate composition and habitat are similar. Much of the substrate is composed of rock or gravel of larger size compared to stations further downstream.

Reference SPC-R-12. Serves as a reference for the downstream locations on Whitewood Creek (WWC-04 through WWC-09). These stations tend to have a higher percentage of finer-grained particles (sand or smaller) than the up-stream stations. The Spearfish Creek location is characterized by the presence of cobble or gravel.

Reference BFR-R-10. This station on the Belle Fourche River is upstream of the confluence with Whitewood Creek and serves as the reference for the sampling station downstream of the confluence (BFR-R-11).

The metrics used to characterize the benthic community are listed in the upper portion of Table 6-16. The procedure used to convert the measured values into an index of benthic community

health (the Biological Condition Category) is shown in Figure 6-8. The resulting Biological Condition Categories for the study sites are summarized in the lower part of Table 6-16. As seen, all Whitewood Creek and Belle Fourche River benthic communities are classified as slightly impaired relative to their respective reference stations, with WWC-06 showing the greatest impairment.

In order to determine if the variability in any of the various metrics of BMI community health were related to COPC concentrations in aquatic media, correlation analyses were performed for both surface water and bulk sediment. For metrics that decrease as water quality decreases, a significant correlation was defined as p value less than 0.05 and an R value less than -0.7. For metrics that increase as water quality decreases, significant correlations were defined as a p value less than 0.05 and an R value larger than 0.7. For sediment, no significant relationships were observed (upper panel). For surface water, a significant relationship was not noted for any COPC, but was for hardness (lower panel). That is, as hardness increased, several BMI metrics related to density and diversity tended to decrease. It is not known whether this correlation is causal, or whether hardness may tend to co-vary with other factors that influence the BMI community.

In interpreting these results, it is important to recognize that the biological potential of a sampling site is determined not only by water quality but also by the quality of the habitat (substrate). The relationship between habitat quality and biological condition can be envisioned as a sigmoid curve, as shown in Figure 6-9. In cases where habitat is good or excellent habitat, degraded environmental conditions (chemical pollution or toxicants) will be readily observable by decreases in the biological condition of the communities present. However, as habitat degrades to a poor condition, the presence of water quality problems may cause less dramatic responses in the communities, mainly because the degraded habitat may shift the community composition toward more tolerant and opportunistic species (USEPA, 1989c).

Table 6-17 summarize the habitat data collected at the site stations and classifies each according to the degree to which they are similar to their respective reference areas, as follows:

Percent of Comparability	Assessment Category
≥90%	Comparable to Reference
75-88%	Supporting
60-73%	Partially Supporting
≤ 58%	Non-Supporting

Figure 6-9 combines the data on habitat quality and Biological Condition Category, and compares the observed and expected relationship between habitat quality and biological condition. As seen, the Biological Condition of benthic communities at stations WWC-02, WWC-03, WWC-04, and BFR-11 are all lower than would be expected based on the habitat quality. This suggests that stressors (possibly including mine-related chemical contaminants) are responsible for the slight impairment in community health. At stations WWC-05, WWC-06, and WWC-09, the Biological Condition score is close to what might be expected based on the habitat quality, while the condition at WWC-08 is slightly higher than what would be expected.

One of the primary factors contributing to the decrease in habitat quality at some stations is increased embeddedness of the substrate. Figures 6-10, 6-11 and 6-12 illustrates how several measures of biotic community health correlate with embeddedness (note: low embeddedness scores correspond to high embeddedness).

#### *Chadwick (2001)*

Chadwick Ecological Consultants, Inc. (2001) collected data on the diversity and density of benthic macroinvertebrate present in April and September, 2000, at four stations in Whitewood Creek (all located downstream of Gold Run Creek), and compared those to observations at a reference location suggested by USEPA on Spearfish Creek. Three samples were collected at each station using a modified Hess sampler. The results are summarized below.

Comparison of BMI Community in Whitewood Creek and Spearfish Creek

BMI Community Index	Whitewood Creek (4 stations)		Spearfish Creek (1 station)	
	April 2000	Sept 2000	April 2000	Sept 2000
Density (number/m <sup>2</sup> )	420-2800	13,000-27,000	11,800	11,500
Number of taxa	32-46	35-42	39	47
S-W Diversity Index	2.9-3.4	2.1-2.3	3.7	3.3
Number of EPT Taxa	6-11	11-16	10	10
Mayflies (% total taxa)	32-61%	72-79%	23%	16%
Contribution dominance (%)	27-51%	52-67%	19%	28%

Source: Chadwick Ecological Consultants, Inc. (2001)

Based on these findings, the author concluded that the benthic community in Whitewood Creek was generally similar to that in Spearfish Creek, and that the community was relatively diverse and included a number of sensitive EPT taxa. The relatively low density noted in Whitewood

Creek in the spring compared to Spearfish Creek was attributed to differences in collection time and the effects of differences in flow.

*Knudson (2000, 2001a, 2001b)*

Knudson (2000, 2001a, 2001b) collected a series of benthic invertebrate samples at five stations on Whitewood Creek, one of which was 400 m above the confluence with Gold Run Creek. This station (designated WC-1) was used as a reference station. Samples (three replicates per station) were collected from moderate- to high grade riffles by the unit-effort traveling kick net method. As noted above, because of the impacts of a release that occurred in 1998, data collected in June and September of 2000 are the judged to be most meaningful basis for an upstream-downstream comparison in Whitewood Creek. Bioassessment scores and ratings were computed using the method shown in Figure 6-8, except that only three metrics were used (taxa richness, percent contribution of dominant taxon, and community loss index). The results are summarized in Table 6-18.

Based on these data, Knudson (2001a, 2001b) concluded that WC-1 was a good reference location for evaluating the biological condition of benthic communities at the other stations on Whitewood Creek. Although a habitat survey was not performed in 2000, habitat quality data from 1997, 1998, and 1999 indicated that the habitat was "partially supporting". Based on this, the author concluded that differences in habitat quality could account, at least in part, for the slight impairment in biological condition observed at the downstream stations.

### 6.5.3 Periphyton Communities

*Knudson (2000, 2001a, 2001b)*

Knudson (2000, 2001a, 2001b) collected samples of periphyton from natural substrates at five stations on Whitewood Creek, one of which was 400 m above the confluence with Gold Run Creek. This station (designated WC-1) was used as a reference station. During examination, algae were classified in two broad classes (diatoms and non-diatoms). The diatom communities were rated using four biological assessment metrics: taxa richness, percent relative abundance (PRA) of the dominant taxon, a similarity index, and a siltation index. The results are summarized below:

Comparison of Diatoms in Whitewood Creek Downstream of Gold Run  
to Whitewood Creek Reference Station

Metric	WC-1 (Reference)		WC-2		GFP-8		GFP-1	
	June	Sept.	June	Sept.	June	Sept.	June	Sept.
Total taxa	33	31	33	34	38	35	33	30
PRA Dominant taxon	60.6	57.7	58.6	21.5	64.2	28.8	44.9	34.7
Similarity Index	--	--	81.4	29.2	42.8	41.2	69.5	57.8
Siltation Index	22.9	15.8	22.3	14.1	20.9	16.4	42.6	14.0

Based on the relatively high PRA of the dominant taxon (*Achnanthes minutissima*) observed at station WC-1, the author concluded that this station may have been subject to stress or impairment and may not be an ideal reference location for the three downstream stations on Whitewood Creek. Nevertheless, the data support the conclusion that the algal community is generally similar across all four stations, with good diversity of taxa. Except for station GFP-1 in June, the siltation index was relatively low at all stations, indicating little effect of embeddedness on the algal community.

## **7.0 ASSESSMENT OF RIPARIAN FLOODPLAIN FUNCTION AND VIABILITY**

This section provides an assessment of the ecological function and viability of the riparian floodplain. The structure and function of the stream corridor is important because it provides a significant portion of the energy, organic matter, and nutrient inputs to the stream, and because stream corridors usually provide high quality edge habitat as well as forage for a variety of relatively sedentary birds, reptiles, amphibians, and mammals. The sedentary species that generally congregate near streams due to habitat and food availability are often preyed upon by more far-ranging species.

In this risk assessment, the health of the riparian floodplain is assessed by focusing on the status of the terrestrial rooted vascular plant community and on soil invertebrates. The terrestrial rooted vascular plant community provides many functions including: erosion prevention (both water and wind), promotion of rainwater percolation, restriction of sheet water flow leading to reduced flooding potential, provision of nesting and cover habitat for wildlife, production of energy via photosynthesis, production of organic matter input (energy) to streams and soil systems, and reduction of surface wind velocity. The soil invertebrate community plays a key role in nutrient cycling and organic matter processing. This community is also an important food resource for the terrestrial wildlife including insectivorous small mammals and birds. These communities are good indicators of riparian floodplain condition because they reside directly in the soil and are not mobile.

### **7.1 Chemicals of Potential Concern for Terrestrial Receptors**

The procedure used to select chemicals of potential concern in soil were presented in Section 3.4. The following COPCs were selected for quantitative evaluation for terrestrial receptors (plants, soil invertebrates):

- |            |              |            |
|------------|--------------|------------|
| • Aluminum | • Copper     | • Nickel   |
| • Antimony | • Iron       | • Silver   |
| • Arsenic  | • Lead       | • Thallium |
| • Barium   | • Manganese  | • Vanadium |
| • Boron    | • Mercury    | • Zinc     |
| • Chromium | • Molybdenum |            |

## 7.2 Comparison of COPC Concentrations to Toxicity Benchmarks

Potential risks to terrestrial receptors from exposure to COPCs in an environmental medium may be characterized by use of a Hazard Quotient (HQ) approach. The HQ is defined as the ratio of the exposure point concentration to the appropriate toxicity benchmark:

$$HQ = \frac{\text{Concentration}}{\text{Benchmark}}$$

If the HQ is less than or equal to one, it is believed that no unacceptable effects will occur in the exposed aquatic population. If the value of HQ exceeds one, then unacceptable effects may occur, with the likelihood and/or severity of effects tending to increase as the value of the HQ becomes larger.

### 7.2.1 Soil Concentrations Compared to Phytotoxicity Benchmarks

Plants are exposed to metals in soil principally through their roots. Exposure may also occur due to deposition of dust on foliar (leaf) surfaces, but this pathway is believed to be small compared to root exposure. Copper and zinc are considered to be essential or beneficial for plant growth (Kabata-Pendias and Pendias, 1992). However, excessive levels of these and other metals in soil may exert a variety of adverse effects on plants including reduced photosynthetic efficiency, reduced seed germination, and reduced root-mass formation. These phytotoxic responses may occur at the scale of the individual plant or may affect the entire plant community, resulting in areas of stressed and unhealthy vegetation. Stressed communities are often subject to invasion by weedy metals-tolerant species which in turn can result in the disruption and displacement of an entire plant community that would otherwise be found in an affected area. In some locations, lethality to plants can result, and areas with little or no vegetative cover may occur.

#### *Soil Concentration Values*

Data on the concentration of COPCs in soils within the floodplain of Whitewood Creek, the Belle Fourche River, and Spearfish Creek were collected by ERT in 1999 (USEPA 2001a). In March, one sample was collected at six stations on Whitewood Creek, and one station each on the Belle Fourche and Spearfish Creek. In August, five individual samples were collected at four stations on Whitewood Creek and one station on Spearfish Creek. These data are summarized in Table 7-1. Data collected from station WWC-R-01 in March 1999 were excluded because these soils were clearly contaminated with arsenic and a number of other metals, and hence are not representative of reference area soils.

### *Phytotoxicity Benchmarks*

A relatively large body of literature exists regarding metal phytotoxicity. These studies have shown that the toxicity of metals in soils may vary widely between different plant species, and also depends on a large number of soil parameters including soil type, organic content, water content, soil condition, soil chemistry, and soil pH (Adriano, 1986). Benchmark values that have been established for phytotoxicity by several different groups (Kabata-Pendias and Pendias, 1992; CH2M Hill, 1987a; CH2M Hill, 1987b; Efroymson et al., 1997a) are summarized in Table 7-2. These values were used as the basis for the phytotoxicity benchmarks used in this risk assessment. When more than one value was available for a chemical, the geometric mean was used. These are summarized in the right-hand column of Table 7-2.

### *HQ Values for Phytotoxicity*

Because plants are not mobile, HQ predictions are calculated on a sample-by-sample basis, rather than on average concentrations over some selected location. Detailed HQ calculations are presented in Appendix H and shown graphically in Figure 7-1. Note that the results in these figures are plotted on a log-scale, so large differences between HQ values are somewhat compressed. The bar for each station reflects the variability in concentration (and hence risk) between different samples of soil from the station. Inspection of these figures reveals the following main conclusions:

- For antimony, barium, copper, lead, mercury, molybdenum, nickel, silver, thallium, and zinc, most or all calculated HQs are below a level of concern, indicating phytotoxicity from these metals in floodplain soils is unlikely.
- HQs for aluminum, boron, chromium, and vanadium are greater than 1E+00 at all stations, including each of the reference locations. This indicates that the selected phytotoxicity benchmark values for these chemicals are probably not appropriate for soil conditions in the Whitewood Creek site and may over-predict risks.
- For arsenic, HQ values are above a level of concern at all site locations, but are below a level of concern at all reference stations. This suggests that arsenic in site soils could be a source of phytotoxicity.
- Manganese HQs tend to follow a pattern that is qualitatively similar to arsenic, with most Whitewood Creek soils at or above a level of concern, while reference areas are below a level of concern. However, the magnitude of the exceedences for manganese are much

smaller than for arsenic, indicating that if manganese is of concern, the severity of the effect is likely to be minor.

As noted above, because the benchmarks used in these calculations are not based on site-specific studies or measurements of phytotoxicity using soils from the Whitewood Creek site, and because there can be large differences in benchmarks between sites and between published values, the true levels of phytotoxicity in Whitewood Creek soils might be either higher or lower than calculated. Because of this uncertainty, these HQ values for plants should only be considered as part of the weight-of-evidence along with the results of site-specific soil toxicity testing with the turnip seed (*Brassica rapa*) and ryegrass (*Lolium perenne*) as well as site-specific measures of the structure and function of the plant community.

### *Predicted Hazards to Plants of Special Concern*

The western prairie fringed orchid (*Platanthera praeclara*) is identified as a federally listed threatened species and of special concern in South Dakota. No data were located on the concentrations of metals in soils at specific locations where this species may occur, and no data were located on the sensitivity of this species to metal-induced phytotoxicity. Therefore, no quantitative conclusions can be drawn regarding species-specific hazards. However, it is expected that the potential exposure and hazards for this species are similar to those for non-protected species in the same area.

### 7.2.2 Seep Water Concentrations Compared to Phytotoxicity Benchmarks

Screening benchmarks for the protection of plants from aqueous exposures have been developed by Oak Ridge National Laboratory (ORNL) (Efroymson et al., 1997). The screening benchmarks developed by ORNL are assumed to be representative of exposures of plants to contaminants measured in soil solutions (e.g., from lysimeter samples or possibly from aqueous extracts of soil) or in very shallow groundwater (e.g., plants in the vicinity of seeps and springs).

Solution benchmarks include data from toxicity tests conducted using whole plants rooted in aqueous solutions. Tests are commonly conducted in this manner because plants are assumed to be exposed to contaminants in the solution phase of soil, and the presence of soil in test systems reduces the experimenter's degree of control over exposure (Efroymson et al., 1997). It should be noted that these benchmarks are to serve primarily for contaminant screening and do not account for site-specific soil and plant characteristics.

The phytotoxicity benchmarks were derived by rank-ordering the lowest observed effect concentration (LOEC) values and then picking a number that approximated the 10th percentile. If there were 10 or fewer values for a chemical, the lowest LOEC was used. If there were more than 10 values, the 10th percentile LOEC value was used. If the 10th percentile fell between LOEC values, a value was chosen by interpolation. Since these benchmarks are intended to be thresholds for significant effects on growth and production, test endpoints that indicate a high frequency of lethality were not appropriate. Therefore, when a benchmark is based on an LC50 or on some other endpoint that includes a 50% or greater reduction in survivorship, the value is divided by a factor of 5, an approximation of the ratio of the LC50 to the EC20. In all cases, benchmark values were rounded to one significant figure. Selected benchmarks are presented in Table 7-3, along with the corresponding HQ values. As seen, all HQ values are below 1E+00 for all COPCs except arsenic. Arsenic seep water concentrations exceed the screening benchmark at all stations except the USGS reference location. These results indicate that phytotoxicity from root exposure to arsenic in seep water could be occurring. However, confidence in this conclusion is limited, for two reasons. First, seep water may not be indicative of soil water in the root zone of riparian area plants. Second, there is low confidence in the screening benchmark for arsenic due to a limited number of literature values, and because the value is not based on site-specific studies.

### 7.2.3 Soil Concentrations Compared to Benchmarks for Soil Organisms

Soil organisms are defined as organisms that live during an essential part of their life cycle in the soil. This includes both soil invertebrates (e.g., worms, some insects and arthropods, etc), and soil microbes (bacteria, fungi, etc.).

Soil organisms are important components of the terrestrial ecosystem not only because they are prey for other species, but also because they contribute substantially to litter breakdown. Soil invertebrates fragment and partially solubilize organic matter, while soil microorganisms mineralize complex organic molecules to simple molecules that can be taken up by roots, or further mineralized to CO<sub>2</sub> and H<sub>2</sub>O (Eijsackers, 1994). Earthworms are probably the most important soil invertebrate in promoting soil fertility (Edwards, 1992). Their feeding and burrowing activities break down organic matter and release nutrients and improve aeration, drainage, and aggregation of soil. Earthworms are also important components of the diets of many higher animals.

### *Soil Concentration Values*

Soil concentration values used to assess risks to soil invertebrates are the same as described above for terrestrial plants.

### *Toxicity Benchmarks for Soil Organisms*

Soil screening benchmarks for the protection of soil organisms and microbial processes have been developed by three different groups, including Oak Ridge National Laboratory (ORNL) (Efroymson et al., 1977b), the National Institute of Public Health and the Environment (Bilthoven, the Netherlands) (RIVM, 1997), and the Canadian Council of Ministries of the Environment (CCME, 1997).

The screening benchmarks developed by Oak Ridge National Laboratory for application at hazardous waste sites (Efroymson et al., 1997b) are derived using a method similar to that used by NOAA to establish the ERLs and ERMs for sediment (Long and Morgan, 1990). The data available on toxicity of a contaminant to soil organisms was reviewed and the LOEC determined. The LOEC is defined as the lowest applied concentration of the chemical causing a greater than 20% reduction in the measured response. In some cases, the LOEC was the lowest concentration tested or the only concentration reported (EC50 or ED50 data). The LOECs were rank ordered and a value selected that approximated the 10th percentile. When a benchmark was based on a lethality endpoint, the benchmark value was divided by 5 to approximate an effects concentration for growth and reproduction. The factor was selected based on the author's judgement. The benchmark values were then rounded to one significant figure (Efroymson et al., 1997b). Efroymson et al. (1997b) developed screening benchmarks for earthworms and microorganisms and microbial soil processes.

The toxicity values developed by these groups are summarized in Table 7-4. As seen, in most cases the benchmarks developed by the different groups for each chemical vary by less than an order of magnitude. An exception is chromium and mercury, for which the range of soil organism TRVs is substantially wider (300-fold). Screening benchmarks for antimony and thallium were not available. For the purposes of this assessment, if multiple benchmarks were available, the benchmark was the geometric mean of the alternative values. These values are shown in the right-hand column of Table 7-4.

## *HQ Values for Soil Organisms*

Detailed HQ calculations for soil organisms are presented in Appendix I and shown graphically in Figure 7-2. Note that the results in these figures are plotted on a log-scale, so large differences between HQ values are somewhat compressed. The bar for each station reflects the variability in concentration (and hence risk) between different samples of soil from the station. Inspection of these figures reveals the following main conclusions:

- HQ values are all at or below a level of concern for barium, boron, copper, lead, mercury, molybdenum, nickel, silver, vanadium, and zinc. This indicates that these metals are not likely to be of concern to soil organisms in floodplain soils.
- HQs for aluminum, iron, and manganese are greater than 1E+00 at all locations, but the values at reference locations are generally similar to the site locations. A generally similar pattern is observed for chromium, although the HQ exceedences are lower. This indicates that the selected soil organism benchmark for these chemicals may over predict risks and may not reflect soil conditions in the Whitewood Creek site.
- Arsenic HQs are above a level of concern at all site locations, and are below a level of concern at all reference locations. This indicates that arsenic in floodplain soils at the site may be toxic to soil invertebrates.

As was discussed above regarding the HQs for phytotoxicity, because none of the toxicity benchmarks used in these calculations are based on site-specific studies or measurements performed using soils from the Whitewood Creek site, and because of the variability between different published benchmarks for soil organisms, the true levels of toxicity in site soils could be either higher or lower than predicted. Because of this uncertainty, the HQ values for soil organisms based on the selected toxicity benchmarks should only be viewed as part of the weight-of-evidence approach along with the results of site-specific soil toxicity testing with the earthworm (*Eisenia foetida*).

### **7.3 Site-Specific Soil Toxicity Tests**

#### **7.3.1 Site-Specific Soil Toxicity Tests with Plants**

Site-specific tests of soil toxicity to plants are available for two species: turnip (*Brassica rapa*) and ryegrass (*Lolium perenne*) (USEPA, 2001b). Seeds were planted in soils from five locations on Whitewood Creek as well as four different reference soils (one each from reference locations

on Whitewood Creek, the Belle Fourche River, and Spearfish Creek, and one laboratory control soil). Plant emergence was measured after 7 days, and plant growth, survival, height, shoot length, and biomass results were measured after 28 days.

#### *Toxicity Results for Turnip Seed*

Turnip seeds require a soil pH between 6.0 to 7.5 in order to germinate. For this reason, the pH of each of the test soils was measured upon initial receipt and after five days of refrigeration. After this time, all but two of the soils (WWC-08 and WWC-R-01 M) were still too alkaline to support growth, so the pH was adjusted by addition of ammonium sulfate. The pH of the soils after adjustment and further refrigeration are shown below:

<b><u>Sample</u></b>	<b><u>Initial pH</u></b>	<b><u>Final pH</u></b>
Laboratory Control	7.80	7.49
BFR-R-10 (ref)	7.94	7.33
SPC-R-12	8.03	7.55
WWC-07	8.37	7.25
WWC-09	8.39	7.51
WWC-R-01 M*	7.28	6.89
WWC-05	8.16	7.4
WWC-06	8.12	7.5
WWC-08*	7.43	7.43

\*Did not require pH adjustment

Table 7-5 presents the toxicity test results for turnip seeds, along with the measured levels of metals in each of the test soils. It is important to note that soils collected from station WWC-R-01 in March 1999 (designated as “WWC-R-01 M”) were later found to have elevated metals concentrations due to the proximity of a railroad turn-around point and therefore results from this station may not be appropriate for use as reference. With the exception of WWC-08 and WWC-R-01 M, no emergence was observed for any of the site soils tested after 7 or 28 days of exposure. The basis for this marked absence of plant survival is unknown, but failure to germinate was observed in all samples treated with ammonium sulfate, while good germination was observed in the untreated soils (including WWC-R-01 M). This finding suggests that the ammonium sulfate treatment may have been responsible for the toxicity rather than the soil itself. Thus, these results do not provide a reliable means of evaluating the potential phytotoxicity of site soils.

### *Toxicity Results for Ryegrass*

Table 7-6 presents the toxicity test results for ryegrass seeds, along with the measured levels of metals and pH in each of the test soils. In this test, the soil from station WWC-R-01 was collected from a location that is not believed to be impacted by metals and is considered to be an appropriate reference material.

As seen, emergence was at or near 100% in all cases, and time to emergence was generally similar for all soils (5-8 days). Statistical comparisons were performed using a one-tailed t-test to determine if the growth response (shoot length, shoot mass, and root mass) of seeds grown in test soils was lower than for the reference soils. The results are summarized below:

- None of the growth responses for seeds grown in soils from WWC-05, WWC-06, or WWC-08 were significantly lower than for seeds grown in soil from WWC-R-01
- None of the growth responses for seeds grown in soils from WWC-05, WWC-06, or WWC-08 were significantly lower than for seeds grown in laboratory control soil, except for shoot length and biomass at WWC-08 ( $p < 0.01$ )
- All of the growth responses for seeds grown in soils from WWC-05, WWC-06, or WWC-08 were significantly lower ( $p < 0.01$ ) than for seeds grown in soil from Spearfish Creek (SPC-R-12), except for root biomass at WWC-05.

Each of the measurement endpoints (days until emergence, mean emergence (%), mean shoot length, mean dry shoot biomass, and mean dry root biomass) was tested for a correlation with soil concentrations of each COPC to determine if there were any significant associations. An association of potential interest was recognized as a statistically significant ( $p < 0.05$ ) negative correlation ( $R < -0.7$ ) between COPC concentration and emergence, shoot length, or biomass, or a significant positive correlation between concentration and days to emergence. The results are shown in Table 7-7. As seen, only one such association was detected: as beryllium concentration increased, the length of time to emergence increased. No association of potential concern was detected for any other COPC for any of the other measures of phytotoxicity. Because this analysis tested 125 different relationships, the occurrence of only one apparently significant relationship could be due to chance rather than an authentic chemical-related effect.

Based on the finding that growth of ryegrass in Whitewood Creek soils downstream from Gold Run Creek is not lower than for soil from a reference area upstream of Gold Run Creek and is also generally similar to laboratory control soil, and that no clear correlation between

phytotoxicity and soil concentration of any COPC could be detected, it is concluded that riparian floodplain soils along Whitewood Creek are not significantly phytotoxic to plants. Growth of ryegrass was substantially greater in the soil from Spearfish Creek than for any of the Whitewood Creek soils or the laboratory control soil. The basis for this difference is not known.

### 7.3.2 Site-Specific Soil Toxicity Tests with Earthworms

Soil toxicity evaluations for the earthworm (*Eisenia foetida*) were used to provide data on the availability and toxicity of contaminants present in site soils to soil invertebrates. Earthworm toxicity was evaluated at five test sites on Whitewood Creek along with four reference soils, including one reference location on Whitewood Creek (WWC-R-01), one on Spearfish Creek, one on the Belle Fourche River, and one laboratory control soil (USEPA, 2001b). It is important to note that soils collected from the Whitewood Creek reference station in March 1999 (designated as “WWC-R-01 M”) were later found to have elevated metals concentrations due to the proximity of a railroad turn-around point and therefore results from this station may not be appropriate for use as reference.

Earthworms were exposed to soils collected in two separate evaluations, a 14-day exposure and a 28-day exposure. At the end of each exposure period, information regarding earthworm survival, length, and weight changes were recorded. These results are presented in Table 7-8. Soil concentrations for each station are presented below the toxicity results.

Statistical comparisons were performed using a one-tailed t-test to determine which measurement endpoints (survival, length, weight change) were different for worms exposed to site soils compared to reference soils. The results are summarized below:

- None of the earthworms survived at WWC-05. This response is statistically significant ( $p < 0.05$ ) compared to all reference soils.
- Survival of earthworms exposed to soils from WWC-06, WWC-07, WWC-08, or WWC-09 was not statistically different from any of the control soils.
- Mean length and mean weight were not significantly different in worms exposed for 14 or 28 days to Whitewood Creek soils compared to laboratory control soil or reference soil from WWC-R-01-M. Compared to Spearfish Creek soil, there was a decrease in length for worms exposed for 14 days (but not 28 days) to soil from WWC-07, and an increase in weight loss for worms from WWC-08 and WWC-09.

Each of the measurement endpoints (survival, average length, average weight loss) was tested for a correlation with soil concentrations of each COPC to determine if there were any significant associations. An association of potential interest was recognized as a statistically significant ( $p < 0.05$ ) negative correlation ( $R < -0.7$ ) between COPC concentration and emergence, shoot length, or biomass, or a significant positive correlation between concentration and days to emergence. The results are shown in Table 7-9. As seen, there are scattered associations of potential relevance (beryllium, cobalt, and copper are associated with effects on length at day 14, and potassium is associated with effects on weight at day 28), but none are consistent across time (day 14 and day 28). This suggests that the apparent associations may be random rather than authentic dose-response effects.

In conclusion, despite the high mortality observed in one soil sample (WWC-05), there is no clear spatial pattern of toxicity and no apparent meaningful associations between any of the earthworm toxicity measurement endpoints and any of the COPCs in soil. This suggests that COPCs in site soil are probably not responsible for the effects observed.

#### **7.4 Comparison of the Vascular Plant Community to Reference**

Areas of stressed or absent vegetation occur at various locations along Whitewood Creek, some of which are probably associated with the presence of tailings deposits. Presented below are descriptions of two studies that provide information on the nature of plant communities within and near the site, but neither of these studies provide data that correlate plant community density or diversity to concentrations of COPC or other soil attributes (pH, organic carbon content, etc.).

##### *Harner and Associates (1991)*

Harner and Associates (1991) performed a survey of terrestrial vegetation along the lower portion of Whitewood Creek (from Interstate 90 to the confluence with the Belle Fourche River). The study included a quantitative assessment of the vegetation in three categories: grassland, woodland/forest, and streamside. Comparison areas were established for grassland and woodland/forest, but no comparison area was established for the streamside area.

Vegetation cover within the streamside unit was variable, ranging from nearly 100% cover in areas immediately adjacent to the creek to sparse cover on gravel terraces. The vegetation consisted mainly of rushes, sedges, and perennial forbs. Gravel terraces also contained Russian olive and young cottonwoods. Perennial grasses comprised about 17% of the cover, while woody species comprised about 18%. The most dominant grass was redtop, along with quackgrass and cordgrass. Dominant forbs included ragweed, dogbane, water hemlock, thistle,

licorice, spearmint, bugleweed, and tansy. The dominant shrub was coyote willow. Cottonwood and willow comprised a majority of the trees present. Because of the absence of a streamside comparison area, this study does not allow a determination of whether the nature or abundance of terrestrial vegetation has been impacted by tailings released from the mine and deposited along the riparian corridor.

*USEPA (2001b).*

USEPA ERT conducted a qualitative survey of the riparian vegetative community at three test sites on Whitewood Creek (WWC-05, WWC-06, WWC-08), along with two reference locations (WWC-R-01 and SPC-R-12). Dominant taxa and broad community types were identified describing the general extent of the vegetation communities present. The plant community identified at each of the sampling locations is qualitatively described in the following subsections:

WWC-R-01. Reference location WWC-R-01 traversed distinct habitat zones along the north side of Whitewood Creek. Nearest to the creek, grasses, willows, and several wildflower species such as goldenrod (*Solidago* spp.) and red clover (*Trifolium pratense*) were dominant vegetation. Species of raspberry (*Rubus* sp.), cinquefoil (*Potentilla* sp.), and rose (*Rosa* sp.) were also found along the stream. Moving up slope from the stream, the next zone consisted of mostly grasses and wildflowers, particularly fescue, Queen Anne's lace (*Daucus carota*), and wildflowers from the *Asteraceae* family. The area furthest from the stream, was dominated by evergreens such as Douglas fir (*Pseudotsuga menziesii*) and ponderosa pine (*Pinus ponderosa*).

WWC-05. Location WWC-05, downstream and on the plains, could be characterized as a floodplain containing grasses, shrubs, and lowland deciduous trees. The areas closest to the stream were covered predominantly by grasses, yellow (*Melilotus officinalis*) and white sweet clover (*M. alba*), and Russian olive. Moving away from the stream, bur oak (*Quercus macrocarpa*), beech (*Fagus* sp.), and willows were found. There were a few dogwood trees present (*Cornus* sp.) and wildflowers could be found throughout the area.

WWC-06. The area including the Berger Seep (WWC-06) could be characterized as disturbed and dominated by grasses. It appeared as though some logging or other activities had occurred at the location in recent years. The dominant trees were willows and Russian olive. Wildflower species such as common tansy (*Tanacetum vulgare*), goldenrod, and spearmint (*Mentha spicata*) were present.

WWC-08. Grasses dominated the vegetative cover at the Siphon area (WWC-08). Willow, beech, and cottonwoods (*Populus* sp.) were scattered throughout the area. Purple prairie clover (*Dalea purpurea*) and yellow sweet clover were the dominant wildflower species. Near the stream, Russian olive and reed grass (*Phragmites* sp.) were abundant.

SPC-R-12. A small area of cottonwoods and willows bisected the Spearfish Creek reference location (SPC-R-12). The area between the trees and the creek was dominated by sweet white clover, with willows and Russian olive interspersed. Within the area of mature willows, Queen Anne's lace was prevalent. West of the zone of trees was a mature meadow consisting of mostly grasses, with Russian olive and immature cottonwoods scattered throughout, marking the transition zone.

The plant species identified at each sampling locations are listed in Table 7-10. As seen, the reference location WWC-R-01 (upstream Whitewood Creek reference) was the most diverse of any of the sites investigated (27 species of plants observed), with a trend toward decreasing diversity as a function of distance further downstream. However, because this site is located high in the Black Hills while the rest of the Whitewood Creek sites selected for are located at lower elevation in the transitional region with the prairie, this site is not considered to be the most appropriate for comparison. Rather, the Spearfish Creek reference site is considered to be more nearly similar to the Whitewood Creek sites. Based on the Spearfish Creek site (18 total species), Whitewood Creek station WWC-05 is judged to be similar (21 species), while sites WWC-06 and WWC-08 are somewhat less diverse (10 species). Several fescue (*Festuca* spp.) grass species were abundant throughout all locations and were the most prevalent vegetation type at each location. Due to the time of year (August), these grasses did not have seed heads allowing for detailed taxonomic identification. A species of willow (*Salix* sp.) was found at all locations and Russian olive trees (*Elaeagnus angustifolia*) were present at four of the five locations.

## **7.5 Comparison of Soil Functions to Reference**

USEPA ERT (USEPA 2001b) conducted a study to evaluate the ecological integrity of the soil ecosystem, including total and active biomass for bacteria and fungi, abundances of protozoans (flagellates, amoebae, and ciliates), nematode abundances, and percent colonization of roots by mycorrhizal fungi. These results are provided in Table 7-11. However, due to a lack of understanding of what range of measures for these various measurement endpoints is associated with normal and impaired soil functioning, these data were not found to be applicable to a quantitative risk evaluation for riparian floodplain soil integrity.

## 8.0 ASSESSMENT OF WILDLIFE VIABILITY

This section presents an assessment of the viability of populations of wildlife receptors that reside in the riparian zone along Whitewood Creek. This may include a wide variety of mammals and birds that span a variety of sizes and feeding guilds. Exposure of wildlife receptors may occur through ingestion of contaminated surface water while drinking, ingestion of contaminated soil or sediment while feeding, and ingestion of contaminated food web items.

### 8.1 Chemicals of Potential Concern for Wildlife Receptors

The procedure used to select chemicals of potential concern for wildlife in surface water, sediment, and soil was presented in Section 3.4. The COPCs that were selected for quantitative evaluation are summarized below:

Quantitative COPCs for Wildlife Receptors		
Surface Water	Sediment	Soil
Arsenic, Zinc	Aluminum, Antimony, Arsenic, Barium, Boron, Cadmium, Chromium, Copper, Lead, Manganese, Mercury, Molybdenum, Vanadium, Zinc	Aluminum, Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Copper, Lead, Manganese, Mercury, Molybdenum, Thallium, Vanadium, Zinc

Any chemical identified as a COPC for one or more abiotic media was assumed to be a COPC for biotic (food web) items as well.

### 8.2 Representative (Surrogate) Species and Exposure Pathways

As discussed in Section 3.3, it is not feasible to evaluate exposures and risks for each avian and mammalian species potentially present within the site. For this reason, specific wildlife species are identified as surrogates (representative species) for the purpose of estimation of exposure and risk in the ERA. The species identified as surrogate species at this site include:

Feeding Guild	Mammal	Bird
Insectivore/soil invertebrates	Masked shrew	American robin, Cliff swallow, American Dipper
Herbivore	Meadow Vole	
Piscivore	Mink	Belted kingfisher
Omnivore	Deer mouse	
Carnivore	Red fox	American kestrel, Great Horned Owl

In accord with the conceptual site model (see Figure 3-1), the exposure pathways that were evaluated for each species are as summarized in Table 8-1.

### 8.3 Hazard Quotient Approach for Risks from Ingestion Exposure

#### 8.3.1 Basic Equations

The basic equation used for calculation of an HQ value for exposure of a terrestrial wildlife receptor to a chemical by ingestion of an environmental medium is:

$$HQ_{i,j,r} = \frac{Conc_{i,j} \times (IR_{j,r} / BW_r) \times DF_{j,r}}{oTRV_{i,r} / RBA_{i,j,r}}$$

where:

$HQ_{i,j,r}$	=	HQ for exposure of receptor “r” to COPC “i” in medium “j”
$C_{i,j}$	=	Concentration of COPC “i” in medium “j” (e.g., mg/kg wet weight)
$IR_{j,r}$	=	Intake rate of medium “j” by receptor “r” (e.g., kg wet weight/day)
$BW_r$	=	Body weight of receptor “r” (kg)
$DF_{j,r}$	=	Dietary fraction of medium “j” by receptor “r” derived from site
$RBA_{i,j,r}$	=	Relative bioavailability of COPC “i” in medium “j” by receptor “r”
$oTRV_{i,r}$	=	Oral toxicity reference value for COPC “i” in receptor “r” (mg/kg-d)

Because all receptors are exposed to more than one environmental medium, the total hazard to a receptor from a specific COPC is calculated as the sum of HQs for that COPC across all media:

$$HQ_{i,r} = \sum HQ_{i,j,r}$$

### 8.3.2 Exposure Areas and Exposure Point Concentrations

#### *Exposure Areas*

Wildlife receptors are generally mobile, and hence may be exposed to a range of different concentration values in water, soil, and food web items as they move throughout their home range. For the purposes of this assessment, the riparian zone along Whitewood Creek and the Belle Fourche River was divided into a number of zones. These exposure zones are listed below and are shown in Figure 8-1.

Exposure Zone	Description
WWC - Reach A	Whitewood Creek upstream of Gold Run Creek (reference area for WWC - Reach B)
WWC - Reach B	Whitewood Creek downstream of Gold Run Creek to the Crook City bridge
WWC - Reach C	Whitewood Creek downstream of the Crook City bridge to Crow Creek confluence
WWC - Reach D	Whitewood Creek from Crow Creek confluence to Belle Fourche River
BFR - Reach A	Belle Fourche River upstream of Whitewood Creek (reference area for BFR - Reach B)
BFR - Reach B	Belle Fourche River downstream of Whitewood Creek
SPC	Spearfish Creek (reference area for WWC - Reach C & D)

These exposure zones are treated as if average concentration levels were similar at all locations within the zone. Thus, all exposure and risk estimates should be interpreted as the average for the zone, and individual receptors with small home ranges might have exposures that are somewhat higher or lower than the zone-wide average.

#### *Exposure Point Concentrations*

The Exposure Point Concentration (EPC) is a conservative estimate of the mean concentration of a COPC in a medium, averaged over the exposure zone of concern. In accordance with USEPA guidance, averages were calculated using  $\frac{1}{2}$  the detection limit for non-detects, and the estimate of the mean that was employed was either the 95% upper confidence limit of the mean (UCL95), or the maximum detected value, whichever was smaller. For the purposes of this assessment, the

95% UCL of the mean was calculated based on the assumption that the data from an exposure area were distributed lognormally.

For biotic samples (food web items), all of the measured concentrations of COPCs are expressed in terms of dry weight. However, all food ingestion factors (kg/day) used to estimate doses for wildlife (presented later) are expressed in units of wet weight. Therefore, concentration values in food items were converted from dry weight to wet weight using the following average dry-weight to wet-weight ratios presented below.

<b>Tissue Type</b>	<b>Conversion Factor (CF)</b>	<b>Source</b>
Vegetation/Plants	0.53	DOI (1998)
Small Mammals	0.32	Sample et al. (1997)
Terrestrial Invertebrate (e.g.: grasshoppers)	0.35	Sample et al. (1997)
Soil Invertebrate (e.g.: earthworms)	0.16	Sample et al. (1997)
Benthic Invertebrate	0.15	USFWS (1998)
Fish	0.24	USFWS (1998)
<b>Wet weight Concentration = Dry weight concentration · CF</b>		

Table 8-2 summarizes the EPCs for each COPC for each medium for each exposure area. These values were used to estimate the average exposure and risk to wildlife receptors in each exposure area.

As seen, samples of some types of food web items were not available for all exposure areas. One way to estimate the levels of COPCs in food web items in these areas is to quantify the relationship between soil COPC concentration and the concentration in the food web item observed at other locations, and to use this equation to predict values. Appendix J summarizes the data that were collected by USEPA (2001b) with the objective of establishing empiric site-specific relationships between COPC levels in soil and in various types of food web items.

However, the observed relationship between COPC concentrations in soil and in most types of food web items is not strong. In order to be meaningful, the slope of the equation relating soil to food web item must be significantly greater than zero, and the coefficient of determination ( $R^2$ ) value must be relatively high (e.g., 0.5 or above). At this site, of 70 different relationships between soil and biotic tissue concentrations that were evaluated, only 9 (13%) met this definition. Likewise, for sediment, only 3 of 28 (11%) were meaningful. Indeed, in many cases,

the concentration of some COPCs in food items tended to decrease as soil or sediment concentration increased (see Appendix J). This lack of apparent correlation is probably attributable to several factors, potentially including analytical variability in both the soil and food web items, variability in the concentration in the tissues of food items as a function of age and species, and relatively low uptake rates of most COPCs from soil into food web items. Regardless of the cause for the apparent lack of correlation, the data are not considered to form a reliable means for estimating food web concentration values at locations where no direct measurements were obtained. Because of this, food web exposures were not evaluated in exposure areas where food web data were lacking. As shown below (see Section 8.3.6), this approach is not likely to result in a substantial underestimate of exposure and risk, since risks to most receptors are due to soil or sediment intake rather than food web exposures.

### 8.3.3 Wildlife Exposure Factors

Exposure parameters and dietary intake factors for each receptor for each medium were derived from the Wildlife Exposure Factors Handbook (USEPA, 1993a), as well as a variety of other sources. In some cases, no quantitative data could be located, so professional judgement was used in selecting exposure parameters. Parameter details and life histories for selected receptors are presented in Appendix B, and the values selected are summarized in Table 8-3 and Table 8-4. All intake values shown in these tables are expressed in terms of wet weight except for soil and sediment, which are expressed as dry weight.

In all cases, the DF term (the fraction of the total dietary intake that comes from within the exposure zone) was assumed to be 1.0. This assumption was used because each of the exposures zones is relatively large, and most terrestrial receptors being evaluated are expected to derive nearly all of their food from the riparian zone along Whitewood Creek or the Belle Fourche River. If any receptors were to derive a significant portion of their diet from areas outside of the zones being evaluated, estimated doses and risks could be lower than predicted.

### 8.3.4 Wildlife TRVs and Relative Bioavailability Factors

Toxicity Reference Values (TRVs) were identified for each COPC for each receptor based on a critical review of published toxicity data. Two secondary sources (Sample et al., 1996, PRC 1997) were used to help identify key toxicity papers. Any paper which was considered by the authors of these reports was obtained and reviewed independently to determine the relevance and reliability of the data for setting a TRV for the representative wildlife receptors of concern.

Two different types of TRVs were developed for each COPC for each receptor. The first type is based on a reported exposure level (dose) that is not associated with any adverse effects to the test organism. This is referred to as the No Observed Adverse Effect Level (NOAEL) based TRV. The second type of TRV is based on a reported exposure level that causes an observable adverse effect, and is referred to as the Lowest Observed Adverse Effect Level (LOAEL) based TRV. This range of TRVs is one way to "bracket" the true threshold for adverse effects.

In all cases, the TRV is expressed in units of ingested dose. However, the value of the TRV depends on how much of an ingested dose is actually absorbed, which in turn depends on the properties of both the chemical and the dose medium. Ideally, toxicity studies would be available that establish empiric TRVs for all site media of concern (water, food, soil, sediment). However, most laboratory tests use either food or water as the exposure medium, and essentially no studies use soil or sediment. Therefore in cases where a TRV is based on a study in which the oral absorption fraction is different than what would be expected for a site medium, it is necessary to adjust the TRV to account for the difference in absorption:

$$TRV(\text{site medium}) = TRV(\text{study medium}) \cdot \left( \frac{\text{Absorption from study medium}}{\text{Absorption from site medium}} \right)$$

The ratio of absorption from the study medium compared to absorption from site medium is referred to as the relative bioavailability (RBA).

When toxicity data were available from studies in food or water, but not both, the RBA for a COPC in food compared to that for water or other soluble forms (e.g., capsule) was assumed to be 0.5 (50%). That is:

$$\begin{aligned} TRV_{\text{water}} &= TRV_{\text{diet}} \times 0.50 \\ TRV_{\text{diet}} &= TRV_{\text{water or capsule}} / 0.50 \end{aligned}$$

This adjustment factor of 50% is based on professional judgement, but is supported by evidence that metals in water or capsule typically exist in a readily bioavailable form, and that dietary materials (proteins, carbohydrates, other minerals) tend to bind metals and/or compete for uptake sites, hence reducing their bioavailability. This concept has been used previously by USEPA in the derivation of diet- and water-based Reference Doses for cadmium and manganese.

Absorption of metals from soil and sediment depend on a number of factors, including the physical/chemical form of the chemical and the particle size. These properties can vary widely from site to site, so in the absence of any site specific data, it was assumed that COPCs in soil

and sediment are absorbed to the same degree as COPCs in food. It is considered likely that this approach may tend to overestimate exposure and risk from ingestion of soil and tailings for some COPCs, but this is not known for certain.

When no reliable toxicity data could be located for a receptor of concern, it was necessary to extrapolate toxicity data from studies using another type of receptor. In addition, in some cases available toxicity data were too limited to allow precise definition of NOAEL and LOAEL values for relevant endpoints. To account for these data gaps, each TRV was derived from the study dose level identified as the NOAEL or LOAEL by dividing by an Uncertainty Factor (UF) as follows:

$$\text{TRV} = \text{Study Dose} / \text{UF}$$

The value of UF was calculated as the product of a series of sub-factors, as shown in Table 8-5. In general, USEPA Region 8 recommends that HQ values be calculated only in cases where the total UF used to derive a TRV is less than 100. For all wildlife TRVs derived for this assessment, the total uncertainty factors were below 100.

Appendix K summarizes the primary literature publications which were reviewed on the toxicity of each chemical, identifies the estimated NOAEL and LOAEL values selected for each receptor and each chemical, provides the uncertainty factors selected in accord with Table 8-5, and provides the final TRVs that are judged to be appropriate for this site. These TRVs are summarized in Table 8-6.

#### 8.3.5 Predicted HQ and HI Values for Ingestion Exposures

Appendix L presents detailed calculations of exposure and risk to each surrogate receptor from each COPC for each exposure medium of concern (see Table 8-1). The results, expressed as the HI for each COPC in each exposure zone, are shown in Table 8-7(a to k). Inspection of these tables reveal the following main conclusions:

- For the great horned owl and the American dipper, predicted HI values do not exceed a level of concern for any COPC at any location
- Several COPCs (including aluminum, antimony, barium lead, manganese, molybdenum, thallium, and vanadium) are predicted to cause HI values above 1E+00 for one or more receptors, but in all cases the HI value exceeds a value of 1E+00 in one or more reference areas as well as site areas. This suggests that the TRVs and/or the RBA values for these

COPCs may be too conservative, since toxicity is not expected to be significant in reference areas. Thus, these HI values should be not be interpreted as strong evidence of potential harm.

- Arsenic is predicted to cause HI values well above 1E+00 for a majority of receptors in most site exposure zones, but not in any reference zones. These elevated HI values are due almost entirely to ingestion of soil or sediment while feeding (see Appendix L), with relatively little contribution from water or food web items. This indicates that arsenic in soil or sediment might pose a health risk to a majority of wildlife receptors, including representatives of nearly all feeding guilds.

All of the calculations above assume that wildlife receptors will ingest all of their drinking water directly from Whitewood Creek. However, some receptors may ingest some water from seep areas as well as from the creek. In order to assess the potential risks from seep water ingestion, a screening level assessment was performed assuming 100% of all water ingested was derived from seeps. The results (presented in Appendix L) indicate that seep water would not be a source of concern to any wildlife receptor.

## **8.4 Direct Observations on Wildlife Species at the Site**

### **8.4.1 Tissue Burdens in On-Site Receptors Compared to Reference**

An alternative approach to estimating the exposure of wildlife species is to measure the concentration of COPCs in their tissues and to compare those measured concentrations to levels measured in receptors from reference areas. This approach has the advantage that it integrates exposures over all sources (surface water, soil, sediment, food web), and accounts for any site-specific factors that might increase or decrease exposure compared to laboratory conditions. If exposures are not higher in site areas than reference areas, it is considered unlikely that the COPCs are of health concern. If tissue levels are significantly increased, this is direct evidence of increased exposure, but may or may not be indicative of a potential toxic effect.

#### *Tissue Burdens in Small Mammals*

At this site, data on COPC concentrations in small mammal tissues were collected by USEPA (2001b). These data are presented graphically in Appendix M. Statistical comparisons of the data were not performed because many data sets contain only 1-3 data points (too few to support a meaningful comparison), and because a number of data sets are heavily influenced by non-detect values. Thus, comparisons between reference locations and site locations was performed

qualitatively, based on visual inspection of the graphs. Based on this approach, only one chemical (arsenic) was judged to occur at clearly and consistently increased concentrations in animals collected from Whitewood Creek sites compared to either the Whitewood Creek or the Spearfish Creek reference areas. The results for arsenic are shown in Figure 8-2. Note that this finding demonstrates that small mammals have increased exposure to arsenic, but in the absence of a tissue level of arsenic that is associated with adverse health effects, this finding alone should not be interpreted as proof that arsenic is causing an adverse effect in small mammals.

### *Tissue Burdens in Birds*

In 1997, swallow nest boxes were placed at the Whitewood Creek siphon (WWC-08) and the Kiery property (WWC-09) as well as at reference locations on Bear Butte Creek in a nearby portion of the Black Hills and the North Platte River near Casper, Wyoming (Custer, 1997). Each box was visited regularly during the nesting period and the number of eggs or young present were recorded. Samples of the eggs, carcasses, liver and diet of the nestlings were analyzed for arsenic content. The results are summarized below.

Sample Type	Mean Concentration of Arsenic (ug/g dry weight) (N)					
	Whitewood Creek				Reference	
	House Wren	Tree Swallow	Barn Swallow	Cliff Swallow	House Wren (a)	Tree Swallow (b)
Egg	ND (6)	ND (1)	30 (1)	ND (1)	ND (3)	ND (1)
Liver	3.2 (6)	ND (1)	2.7 (1)	ND (1)	ND (3)	ND (1)
Chick	14 (6)	ND (1)	1.7 (1)	0.8 (1)	ND (3)	ND (1)
Diet	103 (1)	0.6 (1)	23 (1)	5.2 (1)	ND (1)	1.4 (1)
Nest mud	--	--	810 (1)	202 (1)	--	--

(a) Reference = Casper, WY

(b) Reference = Bear Butte, SD

Inspection of this table reveals that arsenic was detectable in several types of tissues from birds from Whitewood Creek, but not from the reference areas. Arsenic was detectable in the diet (stomach contents) of birds from Whitewood Creek and Bear Butte (reference), but levels were generally higher for Whitewood Creek than the reference area. These data indicate that birds from Whitewood Creek have higher exposure to arsenic than birds from the reference area. However, in the absence of other information, this should not be considered to be evidence of an arsenic-related adverse effect.

#### 8.4.2 Small Mammal Organ Weight and Histopathology

Another way to evaluate the potential impacts of site chemicals of terrestrial receptors is to evaluate field specimens for differences in body or organ weight or the nature and severity of histological lesions compared to specimens from reference areas. Data of this type were collected for small mammals by USEPA (2001b), and the results are summarized below.

##### *Organ Weight*

USEPA (2001b) collected data on body weight and liver, spleen and kidney weight, for the masked shrew, field mouse, and meadow jumping mouse. The ratio of the organ weights to body weight are plotted in Figure 8-3. Inspection of this figure reveals the following:

- There is no clear difference in relative liver weights or relative kidney weights in small mammals collected from White Creek sites compared to reference sites
- There is a tendency for relative spleen weights to be higher in animals from Whitewood Creek sites than reference locations, but the increase in spleen weight could not be correlated with concentrations of any COPC measured in whole body tissue. The cause of this observed effect is unknown.

##### *Histopathology*

USEPA (2001b) performed histopathological examination of samples of liver, spleen, and kidney from the masked shrew, field mouse, and meadow jumping mouse. These results are summarized in Table 8-8. As seen, there appears to be an general increase in the incidence of abnormal histopathology in the spleen, liver, and kidney from small mammals collected onsite compared to the reference areas. Statistical comparisons based on a test of proportions between the incidence of abnormal results at each on-site location and the consolidated reference areas are summarized below:

Location	Statistical Significance (p value) vs Combined Reference Areas		
	Liver	Kidney	Spleen
WWC-05	0.831	0.500	0.085
WWC-06	0.181	0.500	0.005
WWC-08	0.111	0.015	0.348

As seen, two of the results (kidney abnormalities at WWC-08 and spleen abnormalities at WWC-06) are significantly different than for the reference areas, but the lack of a consistent effect across locations decreases confidence that these effects are COPC related.

#### 8.4.3 Population Studies

Several surveys have been performed to identify species of birds and mammals that reside within or near the Whitewood Creek site (Harner and Associates 1990a, 1990b; Knowles 1996a, 1996b). The surveys, described previously in Section 2.5, included information from multiple observation stations established in riparian habitat along Whitewood Creek and in grassland habitat adjacent to Whitewood Creek. These surveys established that there are a large number of avian and mammalian species present in and about the site (see Tables 2-4 and 2-5). However, simple observation of the occurrence of wildlife species in the site area is not evidence that mining-related wastes are having no effect. This type of conclusion would require a reliable quantitative estimate of the species density and diversity that would be expected in the absence of any mining-related impacts, and a reliable statistical comparison of those expected values with the observed values. However, performing such a comparison is very difficult, for several reasons: a) quantitative measurement of the density of mobile wildlife species is difficult, b) the density depends on a large number of independent variables, and density can vary widely from place to place and from time to time, even in the absence of mining-related chemical stress, and c) selection of an appropriate reference area for making quantitative comparisons is very difficult. Thus, these studies may be viewed as evidence that mine-related impacts on the terrestrial vertebrate community have not resulted in any clear and obvious effects, but should not be cited as evidence for a total absence of potential effects.

## **9.0 ASSESSMENT OF AMPHIBIAN COMMUNITY VIABILITY**

This section presents an assessment of the viability of the amphibian community that resides along Whitewood Creek. The diversity, density, and reproductive success of amphibians are often sensitive indicators of environmental stress.

Section 6 (above) presented an evaluation of risks to the aquatic community based on a comparison of measured concentrations of COPCs in surface water to the corresponding AWQC values. It is important to recognize that although the AWQC value is sometimes interpreted as being protective of all aquatic species, this is not the case. Rather, the AWQC value for each COPC is intended to protect 95% of all aquatic species *for which there are adequate toxicity data*. However, toxicity data are often sparse for amphibians, and the final data sets used to derive AWQC values for the COPCs in surface water at this site (aluminum, copper, cyanide, lead, selenium, silver) did not include any amphibian data. Therefore, an alternative approach is needed to assess potential risks to amphibians, as presented below.

### **9.1 Amphibian Toxicity Benchmarks**

USEPA's AQUIRE database summarizes acute toxicity data (LC50 values) for several species of amphibians for all of the COPCs in surface water at this site except cyanide. In accord with the approach used in derivation of AWQC values, the acute TRV is defined as the LC50/2. Acute TRVs generated in this way are assumed to be close to LC0 values. These values are summarized in Table 9-1.

### **9.2 Comparison to Surface Water Concentration Values**

Figure 9-1 presents a graphical comparison of the measured distribution of dissolved COPCs in surface water to the set of amphibian TRVs presented in Table 9-1. For convenience, the corresponding acute and chronic AWQC values are also shown. Inspection of Figure 9-1 reveals the following main points:

- Most AWQC values are sufficiently low that many (but not all) amphibian species would be protected by the AWQC values.
- Concentration values of dissolved aluminum in surface water in Whitewood Creek might occasionally reach a level of concern for the Eastern narrow-mouthed toad, but other amphibian species for which toxicity data exist are not at risk from dissolved aluminum.

Because the concentration of aluminum shows little spatial pattern, aluminum concentrations are probably not substantially increased by mine-related releases.

- Concentrations of dissolved copper, lead, and selenium do not exceed a level of concern based for any of the species for which toxicity data are available.
- Concentrations of dissolved silver reach or exceed a level of concern for two amphibian species (Eastern narrow-mouthed toad, common Indian toad) in the upper reaches of Whitewood Creek, but not at stations below the Berger Seep.

These results suggest that some (but not all) amphibian species may be at risk from dissolved silver in surface water in Whitewood Creek, especially the upstream portion below Gold Run Creek.

### **9.3 Comparison to Seep Water Concentration Values**

As discussed in Section 6-4, data on the concentration of total recoverable COPCs in seep water are available from USGS (2000) for five Whitewood Creek seeps (23R, 23L, 31L, 32L, and 33L) and one reference location, and from ERT (USEPA, 2001a) at four stations along Whitewood Creek (WWC-06, WWC-07, WWC-08, and WWC-09). The concentration values detected in these seeps and a comparison of those values with acute TRVs (based on total recoverable metals) for amphibians are shown in Figure 9-2. Inspection of Figure 9-2 reveals that, with the exception of a few data points for aluminum and one data point for lead, concentrations of COPCs in seep water are below a level of concern for all of the amphibian species for which TRVs could be located. This suggests that seep waters are not likely to be a significant source of exposure or risk to amphibians who may have direct contact with the seep water.

### **9.4 Risk of Toxicity to Amphibians from Sediment**

As discussed in Section 3, amphibians may come into direct contact with sediments, and might ingest some sediments during feeding. Although toxicity data are not available to support risk evaluation risks to amphibians from direct contact with sediments, this exposure pathway is likely to be minor compared to direct contact with COPCs in surface water or seep water. Therefore, risks to amphibians from direct contact with sediment are considered to be of minor concern, and are not evaluated quantitatively.

## **10.0 UNCERTAINTIES**

Quantitative evaluation of ecological risks is limited by uncertainty (lack of knowledge) regarding a number of important data, exposure, toxicity, and risk factors. This lack of knowledge is usually circumvented by making estimates based on whatever limited data are available, or by making assumptions based on professional judgement when no reliable data are available. Because of these assumptions and estimates, the results of the risk calculations are themselves uncertain, and it is important for risk managers and the public to keep this in mind when interpreting the results of a risk assessment.

This section summarizes the key sources of uncertainty influencing the results of the ERA. The discussion of uncertainties is organized according to the components of the ERA.

### **10.1 Uncertainties in Problem Formulation**

#### **10.1.1 Selection of Receptors**

Risks to wildlife are assessed for a small subset of the species likely to be present in the Whitewood Creek Site. The representative wildlife species selected for quantitative evaluation represent a range of taxonomic groups and life history types. An effort was made to select species representing the full range of possible exposures present in the area. These species may not, however, represent the full range of sensitivities present. The species selected may be either more or less sensitive to contaminant exposures than typical species located within the area. In particular, the relative sensitivities of reptiles and amphibians as compared to birds or mammals are unknown. It is assumed that the risks to these organisms are at least qualitatively similar to risks to birds and mammals. However, specific amphibian and reptile species were not selected, as toxicity data for ingestion exposures to contaminants is limited.

#### **10.1.2 Selection of Exposure Pathways**

The exposure pathways selected for evaluation in the ERA are not inclusive of all potential exposure pathways for all ecological receptors. Pathways were excluded from quantitative evaluation either because they are believed to be minor, or because available data are not adequate to support a meaningful quantitative evaluation.

Exposure pathways that could not be evaluated in the ERA included:

***Aquatic Plants.*** Toxicity benchmarks are not available for the exposure of aquatic plants through direct contact with COPCs in sediment. As a result, this exposure pathway could not be evaluated, resulting in a possible underestimation of risks.

***Benthic Invertebrates.*** Data on the impacts to aquatic macroinvertebrates from ingestion of contaminated food items are sparse (Rainbow and Dallinger, 1993; Timmermans, 1993). Although the general consensus is that uptake from food is usually less than from water (Clements, 1991), available data are sufficient to establish that the ingestion pathway can be an important source of exposure to some aquatic macroinvertebrates (Timmermans et al., 1992), and that dietary exposures can be capable of limiting growth in at least some cases (Duddridge and Wainwright, 1980). Based on the lack of data on the toxicity of metals in food chain items on aquatic invertebrate receptors, quantitative prediction of hazard using the traditional HQ and HI approach is not yet possible. To the extent that dietary exposures tend to be less important than water exposures in at least some species, failure to quantify the hazard from the ingestion pathway may not lead to a substantial underestimation of total hazard. However, the food pathway may be more important than the water pathway for some metals and/or some receptor species. Therefore, the inability to quantify hazard from ingestion exposures is a potential source of uncertainty that may tend to underestimate impacts of metal contamination on aquatic macroinvertebrate receptors.

***Fish.*** Although fish ingest surface water during feeding activities, it is assumed that this pathway of exposure is insignificant relative to direct contact with surface water and ingestion of food items. Therefore, this pathway was not evaluated resulting in a possible underestimation of risks. In addition, data on measured COPC concentrations in the tissues of aquatic plants was not available for the Whitewood Creek Site area. As a result, it was not possible to evaluate hazards to fish from the ingestion of aquatic plants which may underestimate the total risks for fish.

***Amphibians.*** There is very little information available regarding the dietary toxicity of chemicals to amphibians. The data that is available is based upon aqueous exposures and evaluate the toxicity of chemicals through direct contact. Based on the lack of toxicity data for dietary exposures to amphibians, all pathways of ingestion could not be evaluated. Therefore, the inability to quantify hazard from ingestion exposures is a potential source of uncertainty that may tend to underestimate impacts of metal contamination on amphibian receptors.

***Terrestrial and Soil Invertebrates.*** No information was available on the toxicity of chemicals in soil solution for terrestrial or soil invertebrates. Without toxicity data, a screening benchmark could not be established for the direct contact exposure of soil invertebrates to seep waters which

have leached into soil and this exposure pathway was not evaluated. Benchmarks were also not available for the dietary exposure of terrestrial invertebrates, therefore exposures from the ingestion of plants and incidental ingestion of soil could not be evaluated. As a result, calculated risks may underestimate the total risks for terrestrial and soil invertebrates.

***All Wildlife Receptors.*** Although selected wildlife receptors may have direct contact with COPCs in surface water, sediment and soil, it is assumed that these pathways of exposure are insignificant relative to ingestion exposures. This is also true with respect to inhalation exposures; it is assumed that risks from inhalation do not contribute significantly to total risks relative to dietary exposures.

## **10.2 Uncertainties in Exposure Assessment**

### **10.2.1 Qualitative COPCs**

As discussed in Section 3, any chemical that was detected in a site medium but which lacks a toxicity value was assigned to a list of Qualitative COPCs (Type 1). Likewise, chemicals that were detected infrequently (<5%), but which had detection limits that were too high to expect the chemical would be detected even if it were present at a level of concern, were assigned to the Qualitative COPC list (Type 2). Table 10-1 summarizes these qualitative COPCs. As seen, a number of such chemicals exist. The inability to quantify the hazard from these chemicals could lead to an underestimation of hazard to some ecological receptors.

With respect to Type 1 qualitative COPCs, absence of a TRV for a chemical is sometimes due to the fact that toxicological concern over that chemical is low. Thus, chemicals that lack TRVs are often supposed to be relatively less hazardous than those for which TRVs exist (although there are likely exceptions to this rule). If so, risks from qualitative Type 1 COPCs at this site are likely not of substantial concern. Similarly, qualitative Type 2 COPCs are not likely to be a source of substantial concern (even if the detection limit is low), since if the chemical were site related or if it were present at a level of substantial health concern, it likely would have been detected more often. Thus, risks from qualitative Type 2 COPCs at this site are also not likely to be of substantial concern.

### **10.2.2 Environmental Concentrations**

In the exposure assessment, the desired input parameter is the true mean concentration of a contaminant within a medium, averaged over the area where exposure occurs. Nearly all of the calculations of receptor exposure and risk begin with measurements of the COPCs in

environmental media. As has been noted in preceding sections, even though there is an extensive database for each of these media, because of the size of the site and because of the substantial variability in concentration values over time and/or space, there is still uncertainty in the true concentration values at any particular site location.

At some locations, COPC concentrations in some prey (food) items (plants, soil invertebrates, terrestrial invertebrates, and small mammals) were not available, and site-specific relationships between soil and the food web item were not robust enough to allow estimation by modeling. Thus, exposure via food web intakes was not quantified at some locations. This will result in an underestimation of exposure and risk, but based on results from other locations where food web data were available, the magnitude of the error is probably small.

Uncertainties in exposure concentration estimates may also arise from variability in sampling and analysis. For example, samples collected for analysis may not be entirely representative of the area being sampled, and random variations in analytical results may lead to small errors in the estimated concentrations in site media. In general, uncertainties related to sampling and analysis are small compared to other sources of uncertainty, and are not a significant source of concern.

For aquatic and soil receptors, exposures are based on the distribution of values measured in individual samples of water, sediment, or soil. For terrestrial wildlife receptors, exposure is based on a conservative estimate of the mean (the 95% UCL or the maximum value). This approach is likely to result in an overestimate of exposure and risk to wildlife.

### 10.2.3 Wildlife Exposure Factors

Even if the concentrations of metals were known with accuracy in all abiotic and all biotic media (food web items), the actual intake of the COPCs by site wildlife receptors would still be uncertain because of the lack of site-specific knowledge of the actual intake rates. The food, soil, water, and sediment intake (ingestion) rates used to estimate COPC doses are derived from literature reports of intake rates by receptors at other locations. These rates may or may not serve as appropriate models for site-specific intake rates at this site. Ingestion-related exposure assumptions for wildlife are based on literature-derived information concerning average body sizes, diet compositions, consumption rates, and metabolic rates. Much of this information is derived from laboratory-reared animals and may not be representative of feral organisms. Moreover, the actual diet composition of an organism will vary daily and seasonally. In addition, some wildlife receptor-specific intake rates are estimated by extrapolation from data on a closely related species or by use of allometric scaling equations (scaling of intake rates based

on body weights). This introduces further uncertainty into the exposure and risk estimates. These uncertainties could either under- or overestimate the actual exposures of wildlife to COPCs in water, sediment, soil, and diet.

#### 10.2.4 Uncertainty in Absorption From Ingested Doses

The toxicity of an ingested chemical depends on how much of the chemical is absorbed from the gastrointestinal tract into the body. However, the actual extent of metal absorption from ingested media (soil, sediment, food, and water) is usually not known. The hazard from an ingested dose is estimated by comparing the dose to an ingested dose that is believed to be safe, based on tests in a laboratory setting. Thus, if the absorption is the same in the laboratory test and the exposure in the field, then the prediction of hazard will be accurate. However, if the absorption of chemical from the site medium is different (usually lower) than occurred in the laboratory study, then the hazard estimate will be incorrect (usually too high). In this assessment, estimates of wildlife exposure due to incidental soil and sediment ingestion conservatively assume a relative bioavailability of 100%. This assumption may overestimate contaminant doses to wildlife doses, since absorption efficiencies for most metals are lower in soil and sediment than in most laboratory studies.

### **10.3 Uncertainties in Effects Assessment**

Toxicity information for many contaminants is often limited. Consequently, there are varying degrees of uncertainty associated with the wildlife toxicity reference values. Sources of uncertainty associated with toxicity values are listed below:

- Toxicity data are not available for all of the species of potential concern at the site. Thus, it is sometimes necessary to estimate toxicity values for a receptor by extrapolating across species. This extrapolation introduces substantial uncertainty into the toxicity value, usually by assuming that the species for which data are lacking might be more sensitive than the species for which data are available. This approach is more likely to overestimate than underestimate risk to ecological receptors.
- The literature-derived data used to identify toxicity benchmarks contain uncertainties related to the application of generic data to site-specific conditions. The toxicity benchmarks identified for the ERA are based on data from a wide range of sites and conditions, many of which may be quite different from the conditions at the Whitewood Creek Site. In some cases, site-specific factors that may tend to modify (often decrease) the toxicity of metals in surface water, sediments, and soil. For example, metals in

surface water may be bound to soluble organic materials that reduce the tendency for the metal to bind to respiratory structures of fish or benthic organisms. Similarly, the presence of organic matter in soil, along with other substances, may have a significant influence on actual toxicity. Thus, risks based on literature-derived toxicity factors may sometimes overestimate risk from site media.

- Most TRV values are derived from studies of the adverse effects of a single contaminant. However, exposures to ecological receptors usually involve multiple contaminants, raising the possibility that synergistic or antagonistic interactions might occur. This sort of interaction is of particular importance with regard to metals, since it is known that the absorption and toxicity of some metals interact in complex ways. However, data are not adequate to permit any quantitative adjustment in toxicity values or risk calculations based on inter-contaminant interactions. This uncertainty may result in over- or underestimates of risk.
- In some cases, TRV data are available only for high dose exposures, and extrapolation to low doses (similar to those at the site) is a source of uncertainty. Likewise, some TRVs are based on relatively short-term exposures, and extrapolation to long-term conditions is uncertain, especially for chemicals that tend to build up in the exposed organism.

#### **10.4 Uncertainties in Risk Characterization**

The basic HQ approach used for estimating exposure and hazard to terrestrial receptors is to estimate the dose and the HQ for each COPC separately, and then to add HQs for a given chemical across all exposure pathways to derive a chemical-specific hazard index (HI). In accordance with USEPA guidance, effects from different COPCs are not added unless reliable data are available to indicate that the two (or more) chemicals act on the same target tissue by the same mode of action. At this site, HI values for each COPC were not added across different chemicals. If any of the chemicals were act by a similar mode of action, total risks could be higher than estimated.

#### **10.5 Summary of Uncertainties**

Based on all of these considerations, the HQ and HI values calculated and presented in this ERA section should be viewed as having substantial uncertainty. Because of the inherent conservatism in the derivation of most of the exposure estimates and the TRVs, these HQ and HI values should generally be viewed as being more likely to be high than low, and should be interpreted in a weight-of evidence approach based on other types of available information as well.

## 11.0 WEIGHT OF EVIDENCE EVALUATION

At this site, three basic types of information are available to help assess the potential impacts of site contaminants on ecological receptors:

### *HQ and HI Values*

HQ values are derived by comparing an estimate of exposure at the site to a literature-based exposure level that is believed to cause no or minimal toxic effects:

$$HQ = \frac{\text{Site Exposure}}{\text{Reference Exposure}}$$

HQ values less than 1E+00 indicate that adverse effects are not expected, while values above 1E+00 indicate effects may occur. Because HQ values are not based on site-specific toxicity data, they do not account for site-specific factors that may either increase or decrease the toxicity of the metals compared to what is observed in the laboratory. For metals, this may include, for example, differences in the physical/chemical form of the metal and hence in the bioavailability and toxicity of the metals in site media compared to laboratory tests. Therefore, HQ values should be interpreted as estimates rather than highly precise predictions.

### *Site-Specific Toxicity Studies*

Site-specific toxicity tests measure the response of receptors that are exposed to site media. The chief advantage of this approach is that site-specific conditions which can influence toxicity in site media are usually accounted for. A potential disadvantage is that, if toxic effects are observed to occur when test organisms are exposed to site media, it is usually not possible to specify which chemical(s) is (are) responsible for the effect. Rather, the results of the toxicity testing reflect the combined effect of the mixture of chemicals present in the site medium, including all of the metals of potential concern as well as any other toxic chemicals which might be present. In addition, it is often difficult to test the full range of environmental conditions which may occur at the site across time and space, so these studies are not always adequate to identify the boundary between exposures that are acceptable and those that are not.

### *Direct Observations of Receptor Diversity and Abundance*

A third approach for evaluating impacts of environmental contamination on ecological receptors is to make direct observations on the receptors in the field, seeking to determine whether any

receptor population has unusual numbers of individuals (either lower or higher than expected), or whether the diversity (number of different species) of a particular category of receptors (e.g., plants, benthic organisms, birds) is lower than expected. The chief advantage of this approach is that direct observation of community status does not require making the numerous assumptions and estimates needed in the HQ approach. However, there are also a number of important limitations to this approach. The most important of these is that both the abundance and diversity of an ecological population depend on many site-specific factors (habitat suitability, availability of food, predator pressure, natural population cycles, meteorological conditions, etc.), and it is often difficult to know what the expected (un-impacted) abundance and diversity of an ecological population should be in a particular area. This problem is generally approached by seeking an appropriate "reference area" (either the site itself before the impact occurred, or some similar site that has not been impacted), and comparing the observed abundance and diversity in the reference area to that for the site. However, it is sometimes quite difficult to locate reference areas that are truly a good match for all of the important habitat variables at the site, so comparisons based on this approach do not always establish firm cause-and-effect conclusions regarding the impact of environmental contamination on a receptor population.

### ***Weight of Evidence Approach***

As discussed above, each of the methods available for evaluating potential impacts of environmental pollution on ecological receptors has advantages and limitations. For this reason, conclusions based on only one method of evaluation may be misleading. Therefore, the best approach for deriving reliable conclusions is to combine the findings of all methods for which data are available, taking the relative strengths and weaknesses of each method into account. If the methods all yield similar conclusions, confidence in the conclusion is greatly increased. If different methods yield different conclusions, then a careful review must be performed to identify the likely basis of the discrepancy, and to decide which method is more likely to yield the correct conclusion.

### ***Scoring Evaluation of Observations***

Evaluation of the weight of evidence on a particular issue is a process that generally requires professional judgment. It is usually helpful to begin by summarizing all of the observations that bear on a particular issue, and then deciding how relevant and how convincing each observation is. That is, does the observation clearly imply that the COPCs have caused a particular effect (e.g., acute lethality), or are there other credible interpretations that might account for the observation? For this ERA, the following qualitative scheme has been used to summarize the results of individual studies or lines of evidence:

Effect Score Criteria	
Score	Meaning
++	Strong evidence that a site exposure is causing an adverse effect
+	Evidence is consistent with, but not proof, that a site exposure is causing an adverse effect
0	Evidence neither supports nor refutes that a site exposure is causing an adverse effect
-	Evidence is consistent with, but not proof, that a site exposure is not causing an adverse effect
--	Strong evidence that a site exposure is not causing an adverse effect

Note that it is not appropriate to simply "average" all of the scores that bear on a particular issue, since different observations are usually not equally relevant. Rather, professional judgement must be used to weight the relative scientific merits of the different types of observations.

### **11.1 Stream Viability and Function**

Table 11-1 summarizes data from the site that bear on the assessment of stream viability and function. The observations are grouped to address each of the testable hypotheses identified in Table 3-4, and important strengths and limitations in the available data are noted. Based on a consideration of all of the information, a weight of evidence conclusion is derived regarding each hypothesis.

Table 11-2 combines data and conclusions across multiple testable hypotheses in order to reach overall conclusions regarding the potential for risk to aquatic receptors from each potential exposure medium, as well as an overall conclusion regarding stream function and viability. As shown in Table 11-2, key conclusions are as follows:

- Risks to aquatic receptors from most COPCs in surface water are generally below a level of concern, although some low level and intermittent stress may occur. Cyanide is not likely to be of concern to stockable size fish, but available data are not sufficient to determine if sensitive life stages of fish or BMI may be at risk from cyanide.

- Risks to aquatic receptors from COPCs in sediment and pore water do not appear to be above a level of concern at most stations, although risks from arsenic and cadmium might be of concern in some locations.
- Seep water is a source of increased COPC concentrations in Whitewood Creek. However, the seep water has little apparent toxicity, and any exposures of aquatic receptors to seep water are minimized by dilution of the seep water in the creek.
- Exposures of aquatic receptors by ingestion of aquatic prey items and/or sediment do not appear to be of concern.
- Population surveys of fish and benthic invertebrates indicate the communities are generally abundant and diverse, although the possibility of an impact cannot be excluded from these data.

Based on these findings, it is concluded that COPCs in the aquatic ecosystem may result in some stress to aquatic receptors, but that the level and severity of any effects are probably not substantial.

## **11.2 Riparian Floodplain Function and Viability**

Table 11-3 summarizes data from the site that bear on the assessment of riparian floodplain viability and function. The observations are grouped to address each of the testable hypotheses identified in Table 3-4, and important strengths and limitations in the available data are noted. Based on a consideration of all of the information, a weight of evidence conclusion is derived regarding each hypothesis.

Table 11-4 combines data and conclusions across multiple testable hypotheses in order to reach overall conclusions regarding each hypothesis as well as an overall conclusion regarding the riparian zone soil community function and viability. As shown in Table 11-4, key conclusions are as follows:

- Site soils are not generally toxic to plants or soil invertebrates.
- If plant roots are exposed to seep water, phytotoxicity from root exposure to arsenic could be occurring, but confidence in this conclusion is low.

- Terrestrial plant and microbial population data are insufficient to support a quantitative conclusion.

Based on these findings, it is concluded that the viability and function of the riparian floodplain is probably not substantially impacted by mining-related releases.

### **11.3 Viability of Terrestrial Wildlife**

Table 11-5 summarizes data from the site that bear on the viability of terrestrial wildlife at the site. The observations are grouped to address each of the testable hypotheses identified in Table 3-4, and important strengths and limitations in the available data are noted. Based on a consideration of all of the information, a weight of evidence conclusion is derived regarding each hypothesis.

Table 11-6 combines data and conclusions across multiple testable hypotheses in order to reach overall conclusions regarding each hypothesis as well as an overall conclusion regarding risks to wildlife receptors. As shown in Table 11-6, key conclusions are as follows:

- Risks to wildlife do not appear to be of significant concern for exposures that occur from ingestion of surface water, seep water, or food items.
- Many terrestrial receptors are predicted to have elevated risk of adverse effects from ingestion of arsenic in soil or sediment.
- Site data confirm that small mammals have increased exposure to arsenic, but there are no independent data from site-specific toxicity testing or quantitative population surveys that can confirm or refute the predicted risk from arsenic.

Based on this, it is concluded that arsenic in soil or sediment may pose a risk to some wildlife receptors, but that this conclusion should be considered tentative unless additional lines of evidence can be added to the evaluation.

### **11.4 Viability of the Amphibian Community**

Table 11-7 summarizes data from the site that bear on the viability of amphibian receptors at the site. The observations are grouped to address each of the testable hypotheses identified in Table 3-4, and important strengths and limitations in the available data are noted. Based on a

consideration of all of the information, a weight of evidence conclusion is derived regarding each hypothesis.

Table 11-8 combines data and conclusions across multiple testable hypotheses in order to reach overall conclusions regarding each hypothesis as well as an overall conclusion regarding risks to amphibians. As shown in Table 11-8, key conclusions are as follows:

- Some species of amphibians (but not all) may be at risk from dissolved COPCs in surface water.
- Risks from sediment or diet cannot be evaluated quantitatively, but are expected to be minor.

Based on this, it is concluded that risks to some amphibians are possible, but that this conclusion should be considered tentative unless additional lines of evidence can be added to the evaluation.

### **11.5 Summary**

Substantial data are available to evaluate the potential risks of COPC-related toxicity to aquatic and terrestrial ecological receptors at the Whitewood Creek site. Based on an evaluation of the weight of evidence across all available lines of evidence, it is concluded that mining-related chemicals probably are causing some toxicological effects on both the aquatic and the terrestrial ecosystems, but that these effects are generally low level and are probably not sufficient to result in substantial disruption of either aquatic or terrestrial ecosystem function or viability.

## 12.0 REFERENCES

- Adriano DC. 1986. *Trace Elements in the Terrestrial Environment*. Springer-Verlag, New York. 553 pp.
- Ankley, G.T. 1996. Evaluation of Metal/Acid-Volatile Sulfide Relationships in the Prediction of Metal Bioaccumulation by Benthic Macroinvertebrates. *Environ. Toxicol. Chem.* 15:2138-2146.
- Ankley, G.T., D.M. Di Toro, D.J. Hansen and W.J. Berry. 1996. Technical Basis and Proposal for Deriving Sediment Quality Criteria for Metals. *Environ. Toxicol. Chem.* 15:2056-2066.
- Batt, J.E. 1988. *Aging of Tailings Deposits by Tree Ring Analysis. Whitewood Creek CERCLA Site, Whitewood Creek, South Dakota*. Prepared for HMC by John E. Batt, Pope & Talbot, Land Forester, March 7, 1988.
- Callahan, M.A. et al. 1979. *Water-related environmental fate of 129 priority pollutants. Vol 1*. EPA-440/4-79-029a. National Technical Information Service (NTIS), Springfield, Virginia.
- Carl GC. 1936. Food of the Coarse-Scaled Sucker (*Catostomus macrochielus* Girard). *J. Biol. Bd. Can.* 3:20-25.
- Canadian Council of Ministers of the Environment (CCME). 1997. *Recommended Canadian Soil Quality Guidelines*. March 1997.
- CH2M Hill. 1987a. *Assessment of the Toxicity of Arsenic, Cadmium, Lead and Zinc in Soil, Plants and Livestock in the Helena Valley of Montana for East Helena Site (ASARCO), East Helena, Montana*. EPA Work Assignment No. 68-8L30.0. May.
- CH2M Hill. 1987b. *Assessment of the Toxicity of Copper, Mercury, Selenium, Silver and Thallium in Soil, Plants and Livestock in the Helena Valley of Montana for East Helena Site (ASARCO), East Helena, Montana*. EPA Work Assignment No. 68-8L30.0. November.
- Chadwick Ecological Consultants, Inc. (CEC). 2001. *Aquatic Biological Monitoring of Whitewood Creek and Spearfish Creek, South Dakota - 2000*. Prepared for Homestake Mining Company, May 2001.

Chadwick Ecological Consultants, Inc., KRW Consulting, Inc., Remediation Technologies, Inc., and Times Limited (Chadwick et al.). 1997. *Status Report and Technical Support Document for the 1997 5-Year Review, Whitewood Creek Superfund Site*. Prepared for Homestake Mining Company, January 31, 1997.

Chadwick & Associates, Inc. (Chadwick). 1996. Unpublished Information as cited in Chadwick Ecological Consultants, Inc., 1997.

Chadwick & Associates, Inc. (Chadwick). 1990a. *Aquatic Biological Survey of Whitewood Creek and the Belle Fourche River, South Dakota*. May 1990. Report prepared for Whitewood Development Corporation.

Chadwick & Associates, Inc. (Chadwick). 1990b. *Aquatic Biological Survey of Whitewood Creek and the Belle Fourche River, South Dakota, September 1990*. Report prepared for Whitewood Development Corporation.

Custer, T.W. 1997. Progress Report. *Heavy Metal Exposure of House Wrens and Swallows Nesting near Whitewood Creek, South Dakota*. Biological Resources Division, USGS, Upper Mississippi Science, Center, La Crosse, WI 54602.

DOI. 1998. Data provided to EPA (Dale Hoff) by DOI (Karl Ford).

Duddridge JE, Wainwright M. 1980. Heavy Metal Accumulation by Aquatic Fungi and Reduction in Viability of *Gammarus pulex* Fed Cd+2-Contaminated Mycelium. *Water Res.* 14:1605-1611.

Edwards, C.A. 1992. Testing the effects of chemicals on earthworms: The advantages and limitations of field tests. In: *Ecotoxicology of Earthworms*. P.W. Greig-Smith et al. (eds) Intercept Ltd. pp. 75-84.

Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997a. *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision*. Prepared for the U.S. Department of Energy, Office of Environmental Management by Lockheed Martin Energy Systems, Inc. managing the Oak Ridge National Laboratory (ORNL). ORNL publication ES/ER/TM-85/R3, November.

Efroymson, R.A., M.E. Will and G.W. Suter II. 1997b. *Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision*. Prepared for the U.S. Department of Energy, Office of Environmental Management by Lockheed Martin Energy Systems, Inc. managing the Oak Ridge National Laboratory (ORNL). ORNL publication. ES/ER/TM-126/R2, November.

Eijsackers, H. 1994. Ecotoxicology of Soil Organisms: Seeking the Way in a Pitch-Dark Labyrinth. In: *Ecotoxicology of Soil Organisms*. M.H. Donker, H. Eijsackers and F. Heimbach. Eds. CRC Press.

Environ Corp (Environ). 1985. *Assessment of Exposure and Possible Effects on Human Health of Gold Mine Tailings in the Whitewood Creek Area of South Dakota*. Prepared by Environ, Corp for Homestake Mining Corporation. April 10, 1985. Draft.

Environmental Response Team (ERT). 1999a. *Quality Assurance Workplan Whitewood Creek Ecological Risk Assessment, Lead, South Dakota*. Prepared by Mark Sprenger (U.S. EPA Environmental Response Team) and Barry Forsythe (Environmental Response Team Center). February.

Environmental Response Team (ERT). 1999b. *Supplemental to Quality Assurance Work Plan Whitewood Creek Ecological Risk Assessment, Lead, South Dakota*. Prepared by Mark Sprenger, Environmental Response Team, Edison NJ, and Barry Forsythe, ERTC/REAC. June.

Fox Consultants, Inc. 1984a. *Whitewood Creek Study, Phase I*. Prepared for the South Dakota Department of Water and Natural Resources Office of Air Quality and Solid Waste. April 16, 1984

Fox Consultants, Inc. 1984b. *Whitewood Creek Study, Phase II*. Prepared for the South Dakota Department of Water and Natural Resources Office of Air Quality and Solid Waste, Homestake Mining Company and the United States Environmental Protection Agency. November 1984.

Geochemical Engineering Incorporated. 1988. *Selenium Sources, Occurrences, and Mobility along Whitewood Creek, South Dakota*. Prepared for HMC by Geochemical Engineering Incorporated. March 1988.

Hagler Bailley. 1998. Electronic files received from Hagler Bailley for the seep survey conducted April 27-28, 1998.

Hansen DJ, Berry WJ, Mahoney JD, Boothman WS, Di Toro DM, Robson DL, Ankley GT, Ma D, Yan Q, Pesch CE. 1996. Predicting the Toxicity of Metal-Contaminated Field Sediments Using Interstitial Concentration of Metal and Acid-Volatile Sulfide Normalizations. *Environ. Toxicol. Chem.* 15:2080-2094.

Harner & Associates, Inc. 1991. *Vegetation of Whitewood Creek, Lawrence, Meade and Butte Counties, South Dakota*. Prepared for the Whitewood Development Corporation, Lead, South Dakota. March, 1991.

Harner and Associates, Inc. 1990a. *Wildlife Survey of Whitewood Creek in Lawrence, Meade and Butte Counties, South Dakota*. Prepared for the Whitewood Development Corporation, Lead, South Dakota. February 28, 1990.

Harner & Associates, Inc. 1990b. *Second Year Baseline Wildlife Survey of Whitewood Creek in Lawrence, Meade and Butte Counties, South Dakota*. Prepared for the Whitewood Development Corporation, Lead, South Dakota. December.

Herricks, E.E. 1982. *Bioassessment of Whitewood Creek Lawrence and Mead Counties, South Dakota*. Prepared for the Homestake Mining Company, Lead, South Dakota

Hess, W.L., R.L. Brown and J.F. Heisinger. 1975. Mercury Contamination of Birds from a Polluted Watershed. *Journal of Wildlife Management*. 39 (2):299-304.

ICF Incorporated (ICF). 1989. *Feasibility Study for Whitewood Creek, South Dakota, CERCLA Site Volume I, II, & Subsection 1.7*. Prepared for Homestake Mining Company by ICF Technology for submission to USEPA Region VIII. December 8.

Industrial Waste Management, Ltd. 1988. *Evaluation of Aquatic Life Impacts Presented in the Draft Battelle Whitewood Creek Endangerment Assessment*. Prepared by T.I. Mudder. March 14, 1988.

ISSI Consulting Group, Inc. (ISSI). 1998. *Screening Level Ecological Risk Assessment, Whitewood Creek Site, Lead, South Dakota*. Prepared for USEPA Region 8. October 1998.

Ingersoll, C.G.; P.S. Haverland, E.L. Brunson, T.E. Canfield, F.J. Dwyer, C.E. Henke, N.E. Kemble, D.R. Mount and R.G. Fox. 1996. Calculation and Evaluation of Sediment Effect Concentrations for the Amphipod *Hyaella azteca* and the Midge *Chironomus riparius*. *Journal of Great Lakes Research*. 22 (3):602-623.

Jacobs Engineering. 1989. *Final Endangerment Assessment Summary Document for Whitewood Creek Superfund Site*. Prepared by Jacobs Engineering for USEPA Region VIII. July 1989.

Jarvinen, A.W., G.T. Ankley, W.A. Stubblefield, C.G. Ingersoll. 1999. *Linkage of Effects to Tissue Residues: Development of a Comprehensive Database for Aquatic Organisms Exposed to Inorganic and Organic Chemicals*. SETAC Technical Publication. ISBN 1-880611-13-9. 364pp.

Kabata-Pendias, A. and H. Pendias. 1992. *Trace Elements in Soils and Plants*, 2nd Edition, CRC Press, 365 pgs.

Knowles, C.J. 1996a. *Whitewood Creek Biological Survey Summary, 1996*. Prepared by Craig J. Knowles, Fauna West Wildlife Consultants for Whitewood Creek Development Corporation, Lead, South Dakota. January 30, 1996.

Knowles, C.J. 1996b. *Whitewood Creek Biological Survey Summaries 1996 Breeding Bird Survey Narrative*. Prepared by Craig J. Knowles, Fauna West Wildlife Consultants for Whitewood Creek Joint Venture, Lead, South Dakota. October 21, 1996.

Knudson, K. 2000. *An Evaluation of the Biological Communities of Whitewood Creek near Deadwood, South Dakota - September 1999 Data*. Prepared for Homestake Mining Company by KNK Aquatic Ecology, March 2000.

Knudson, K. 2001a. *An Evaluation of the Biological Communities of Whitewood Creek near Deadwood, South Dakota - June 1998, 1999 and 2000*. Prepared for Homestake Mining Company by KNK Aquatic Ecology, March 2001.

Knudson, K. 2001b. *An Evaluation of the Biological Communities of Whitewood Creek near Deadwood, South Dakota - September 1995 to 2000*. Prepared for Homestake Mining Company by KNK Aquatic Ecology, April 2001.

Lange-Bertalot, H. 1979. Pollution Tolerance of Diatoms as a Criterion for Water Quality Estimation. *Nova Hedwigia* 64: 285-304 (as cited by Chadwick Ecological Consultants, Inc., et al., 1997).

Long E.R., D.D. MacDonald, J.C. Cubbage, and C.G. Ingersoll. 1998. Predicting the Toxicity of Sediment-Associated Trace Metals with Simultaneously Extracted Trace Metal:Acid-Volatile Sulfide Concentrations and Dry Weight-Normalized Concentrations: A Critical Comparison. *Environ. Toxicol. Chem.* 17:972-974.

Long, ER, D.D. MacDonald, S.L. Smith, F.D. Calder. 1995. Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. *Environmental Management*. Vol. 19, No. 1, pp. 81-97.

Long, E.R. and L.G. Morgan. 1990. *The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program*. NOAA Technical Memorandum NOS OMA 52. Seattle, Washington. March.

Macaphee C. 1960. Postlarval Development and Diet of the Largescale Sucker, *Catostomus macrocheilus*, in Idaho. *Copeia* 1960 (No. 2) 119-125.

MacDonald Environmental Sciences Ltd. (MES) 1994. *Approach to the Assessment of Sediment Quality in Florida Coastal Waters. Vols I to IV*. Prepared for the Florida Department of Environmental Protection. November.

MacDonald, DD, CG Ingersoll, and TA Berger. 2000. Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. *Arch Environ Contam Toxicol* 39:20-31.

Mahony, J.D., D. M. Di Toro, A.M. Gonzales, M. Curto, M. Dilg, L.D. De Rosa, and L.A. Sparrow. 1996. Partitioning of Metals to Sediment Organic Carbon.. *Environ. Toxicol. Chem.* 15:2187-2197.

Mudder, T.I. 1989. Memorandum to Fred Fox dated May 31, 1989 from T.I. Mudder of Steffen, Robertson and Kirsten Consulting Engineers. RE: Impact of High Flow Events on the Potential for Exceedance of Aquatic Life Criteria for Arsenic.

Papageorgiou NC, Neophytou CN, Vlachos CG. 1984. Food and Feeding of Brown Trout (*Salmo trutta fario* L.) in Aspropotamos Stream, Greece. *Pol. Arch. Hydrobiol.* 3:277-285.

Persaud D, R. Jaagumuagi, and A. Hayton. 1993. *Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario*. Water Resources Branch, Ontario Ministry of the Environment and Energy. August, 1993.

PRC. 1997. *Development of Toxicity Reference Values as Part of a Regional Approach for Conducting Ecological Risk Assessments at Naval Facilities in California*. Draft Report prepared for Dept. of the Navy by PRC Environmental Management, San Francisco CA.

Prothro M. 1993. Office of Water Policy and Technical Guidance on Interpretation and Implementation of Aquatic Life Metals Criteria. Memorandum to Water Management Division Directors and Environmental Services Directors, Regions I-X. October 1, 1993.

Rainbow PS, Dallinger R. 1993. Metal Uptake, Regulation, and Excretion in Freshwater Invertebrates. In: Dallinger RD, Rainbow PS, LaPoint T, Grieg-Smith PW. (eds.) *Ecotoxicology of Metals in Invertebrates*. SETAC Special Publication Series. Lewis Publishers.

Rijksinstituut Voor Volksgezondheid en Milieu (RIVM). 1997. *Maximum Permissible Concentrations and Negligible Concentrations for Metals, Taking Background Concentrations into Account*. Crommentuijn et al. National Institute of Public Health and the Environment. Report No 601501 001. Bilthoven, the Netherlands.

Sample BE, Alpin MS, Efromyson RA, Suter GW, Welsh CJE. 1997. *Methods and Tools for Estimation of the Exposure of Terrestrial Wildlife to Contaminants*. Oak Ridge National Laboratory, Oak Ridge, TN. ORNL/TM-13391. October 1997.

Sample BE, Opresko DM, Suter GW II. 1996. *Toxicological Benchmarks for Wildlife: 1996 Revision*. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-86/R3. June 1996.

SDDENR, 1998a. In the Matter of Homestake Mining Company's Discharge to the Environment - Notice of Violation and Order. From: State of South Dakota, Department of Environment and Natural Resources. To: Vern Baker, General Manager, Homestake Mining Company. December 16, 1998.

SDDENR, 1998b. In the Matter of Homestake Mining Company's Discharge to the Environment - Settlement Agreement. From: State of South Dakota, Department of Environment and Natural Resources. To: Vern Baker, General Manager, Homestake Mining Company. December 24, 1998.

Skaar D. 1998. Comments submitted by Don Skaar, Montana Department of Fish, Wildlife and Parks to EPA (Dale Hoff, Scott Brown) in a letter dated June 18, 1998.

Timmermans KR. 1993. Accumulation and Effects of Trace metals in Freshwater Invertebrates. In: Dallinger RD, Rainbow PS, LaPoint T, Grieg-Smith PW. (eds.) *Ecotoxicology of Metals in Invertebrates*. SETAC Special Publication Series. Lewis Publishers.

Timmermans KR, Spijkerman E, Tonkes M, Govers H. 1992. Cadmium and Zinc Uptake by Two Species of Aquatic Invertebrate Predators from Dietary and Aqueous Sources. *Can. J. Fish. Aquat. Sci.* 49:655-662.

United States Environmental Protection Agency (USEPA). 2001a. *Final Report March 1999 Aquatic Sampling Activities in Support of the Whitewood Creek Ecological Risk Assessment, Lead, South Dakota*. Prepared by the USEPA Environmental Response Team (ERT) Center and the Response Engineering and Analytical Contract/Environmental Response Team, Lockheed Martin. February 2001. 2 Volumes.

United States Environmental Protection Agency (USEPA). 2001b. *Final Report 1999 Terrestrial Sampling Activities in Support of the Whitewood Creek Ecological Risk Assessment, Lead, South Dakota*. Prepared by the USEPA Environmental Response Team (ERT) Center and the Response Engineering and Analytical Contract/Environmental Response Team, Lockheed Martin. February 2001. 2 Volumes.

United States Environmental Protection Agency (USEPA). 2001c. *Update of Ambient Water Quality Criteria for Cadmium*. Office of Water, EPA-822-R-01-001.

United States Environmental Protection Agency (USEPA). 2001d. *Ecological Risk Assessment, Clark Fork River Operable Unit Milltown Sediments/Clark Fork River Superfund Site, Montana*. Public Review Draft. Prepared by ISSI Consulting Group. September 2001.

United States Environmental Protection Agency (USEPA). 1999a. *National Recommended Water Quality Criteria - Correction*. Office of Water, EPA-822-Z-99-001.

United States Environmental Protection Agency (USEPA). 1998. *Guidelines for Ecological Risk Assessment*. Final. Risk Assessment Forum, Washington, D.C. EPA/630/R-95/002F. April.

United States Environmental Protection Agency (USEPA). 1997a. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*. Interim Final. U.S. Environmental protection Agency, Environmental Response Team (Edison, NJ). June 5, 1997.

United States Environmental Protection Agency (USEPA). 1997b. *Revision to Rapid Bioassessment Protocols for use in Streams and Rivers, Benthic Macroinvertebrates and Fish*. Office of Water, EPA/841/D-97-002.

United States Environmental Protection Agency (USEPA). 1996a. *Proposed Guidelines for Ecological Risk Assessment*. EPA/630/R-959002B. August, 1996.

United States Environmental Protection Agency (USEPA). 1996b. *1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water*. U.S. Environmental Protection Agency, Office of Water. September, 1996. EPA-820-B-96-001.

United States Environmental Protection Agency (USEPA). 1993a. *Wildlife Exposure Factors Handbook, Volumes I and II*. EPA/600/R-93/187a and b.

United States Environmental Protection Agency (USEPA). 1993b. *Guidelines for Deriving Site-Specific Sediment Quality Criteria for the Protection of Benthic Organisms*. EPA-822-R-93-017. Office of Water, Office of Science and Technology, Health and Ecological Criteria Division. September.

United States Environmental Protection Agency (USEPA). 1992. *Framework for Ecological Risk Assessment*. *Risk Assessment Forum*. EPA/630/R-92/001. February 1992.

United States Environmental Protection Agency (USEPA). 1990a. *Superfund Record of Decision: Whitewood Creek, SD*. Office of Emergency and Remedial Response. EPA/ROD/R08-90/028, March, 1990.

United States Environmental Protection Agency (USEPA). 1990b. *Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters*. Office of Research and Development, EPA/600/4-90/030.

United States Environmental Protection Agency (USEPA). 1989a. *Endangerment Assessment for the Whitewood Creek Superfund Site, Southwestern South Dakota*. Volumes I and II. Office of Health and Environmental Assessment, Office of Research and Development, Washington, D.C., OHEA-E-269. Final Draft. March 1989.

United States Environmental Protection Agency (USEPA). 1989b. *Risk Assessment Guidance for Superfund Volume II Environmental Evaluation Manual. Interim Final*. Office of Emergency and Remedial Response. Washington, D.C. EPA/540/1-89/001. March 1989.

United States Environmental Protection Agency (USEPA). 1989c. *Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish*. Office of Emergency and Remedial Response. Washington, D.C. EPA/440/4-89/001. March 1989.

United States Environmental Protection Agency (USEPA). 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*. EPA/540/G-89/004. OSWER Directive 9355.3-01. Office of Emergency and Remedial Response, Washington DC. October.

United States Environmental Protection Agency (USEPA). 1985. *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses*. U.S. Environmental Protection Agency. Office of Research and Development. January, 1985. NTIS Document Number PB85-227049.

United States Environmental Protection Agency (USEPA). 1984. *Ambient Water Quality Criteria for Cyanide - 1984*. U.S. Environmental Protection Agency. Office of Water Regulations and Standards Division. January, 1985. 49.

United States Environmental Protection Agency (USEPA). 1983. *Hazardous Waste Land Treatment*. EPA/SW874/1983. 671pp.

United States Fish and Wildlife Service (USFWS). 1998. Unpublished data on wet-weight to dry-weight ratios for fish, benthic invertebrates and aquatic plants collected in Montana. Data provided in letter from Kemper M. McMaster (USFWS) to Scott Brown (USEPA), dated June 30, 1998.

United States Geological Survey (USGS). 2000. *The toxicity to fathead minnow of seep waters along Whitewood Creek, South Dakota*. Final Report for the Cheyenne River Sioux Tribe, Eagle Butte, SD. Prepared by Hamilton, S.J. and Buhl, K.J.

United States Geological Survey (USGS). 1990. *U.S. Geological Survey Applied Research Studies of the Cheyenne River System, South Dakota: Description and Collection of Data, Water Years 1987-88*. Edited by Kimball E. Goddard. USGS Open File Report (OFR) 89-580.

United States Geological Survey (USGS). 1988a. *Composition, Distribution, and Hydrologic Effects of Contaminated Sediments Resulting from the Discharge of Gold Milling Wastes to Whitewood Creek at Lead and Deadwood, South Dakota*. By Kimball Goddard. USGS Water Resources Investigations Report 87-4051.

United States Geological Survey (USGS). 1988b. *Field and Laboratory Data Describing Physical and Chemical Characteristics of Metal-Contaminated Flood-Plain Deposits*

*Downstream from Lead, West-Central South Dakota.* Edited by Donna C. Marron. U.S. Geological Survey Open File Report (OFR) 88-349.

United States Geological Survey (USGS). 1988c. *U.S. Geological Survey Toxic Substances Hydrology Program - Surface Water Contamination: Proceedings of the Technical Meeting, Denver, Colorado, February 2-4, 1987.* Edited by G.E. Mallard. USGS Open File Report 87-764. "Arsenic Concentrations of Selected Benthic Insects in Whitewood Creek and the Belle Fourche River, South Dakota" by D.J. Cain et al., p. 55-60.

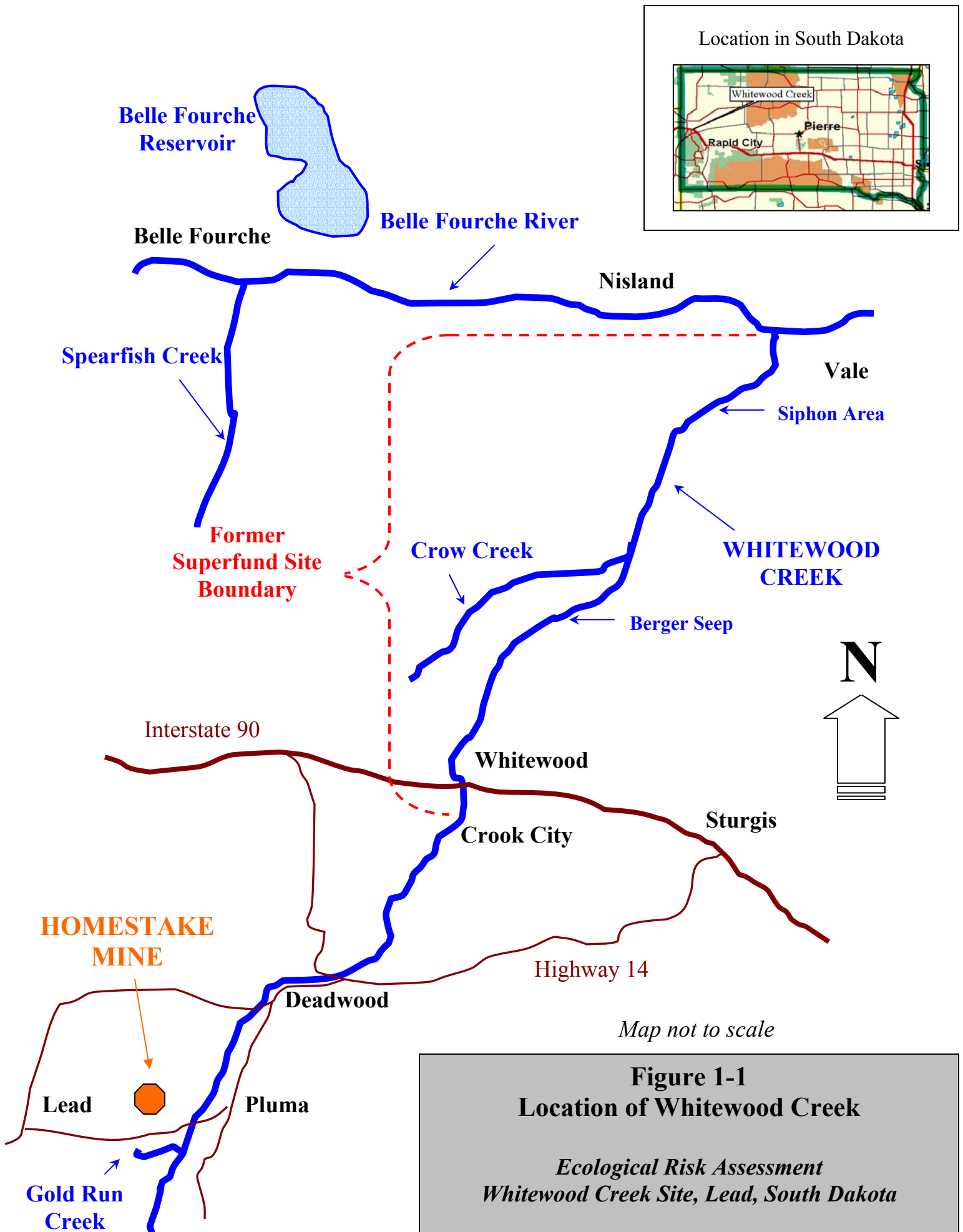
United States Geological Survey (USGS). 1988d. *U.S. Geological Survey Toxic Substances Hydrology Program - Proceedings of the Technical Meeting, Phoenix, Arizona, September 26-30, 1988.* Edited by G.E. Mallard. USGS Water Resources Investigation Report 88-4220. "Temporal and Spatial Variability of Arsenic in Benthic Insects from Whitewood Creek, South Dakota" by D.J. Cain et al., p. 257- 267.

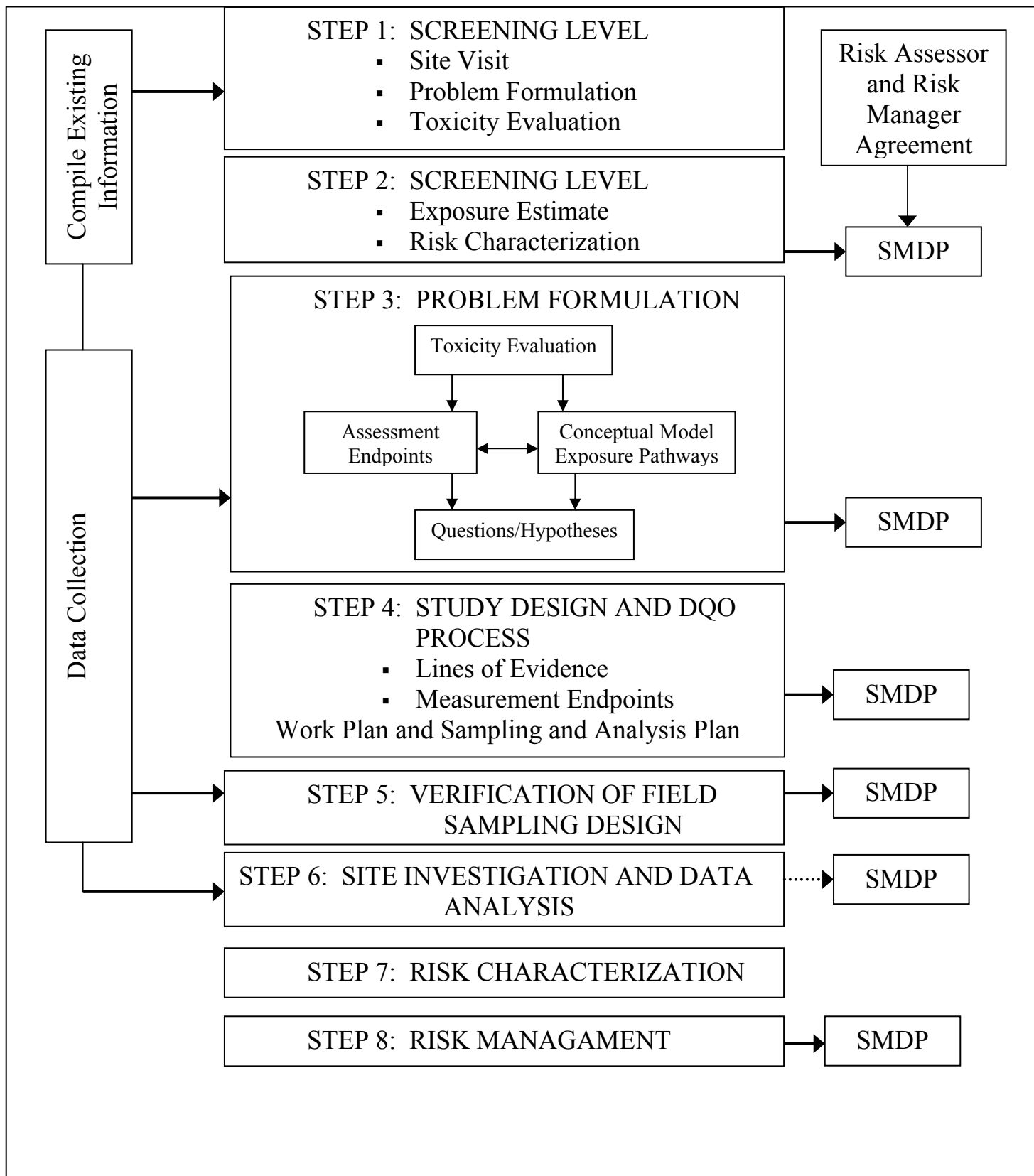
United States Geological Survey (USGS). 1985. *Composition, Distribution and Hydrologic Effects of Mine and Mill Wastes Discharged to Whitewood Creek at Lead/Deadwood, South Dakota.* Draft. Water Resources Investigation Report 85. By Kimball Goddard.

**-FINAL-  
ECOLOGICAL RISK ASSESSMENT  
WHITEWOOD CREEK SITE FIVE YEAR REVIEW  
LEAD, SOUTH DAKOTA**

**July 2002**

**Figures**





**Figure 1-2 Eight Step Process for Ecological Risk Assessment at Superfund Sites (USEPA, 1997)**



Figure 2-1. Homestake Open Pit

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*



Figure 2-2. Gold Run Creek

*Ecological Risk Assessment*

*Whitewood Creek, Lead, South Dakota*



Figure 2-2 (cont.) Gold Run Creek

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*



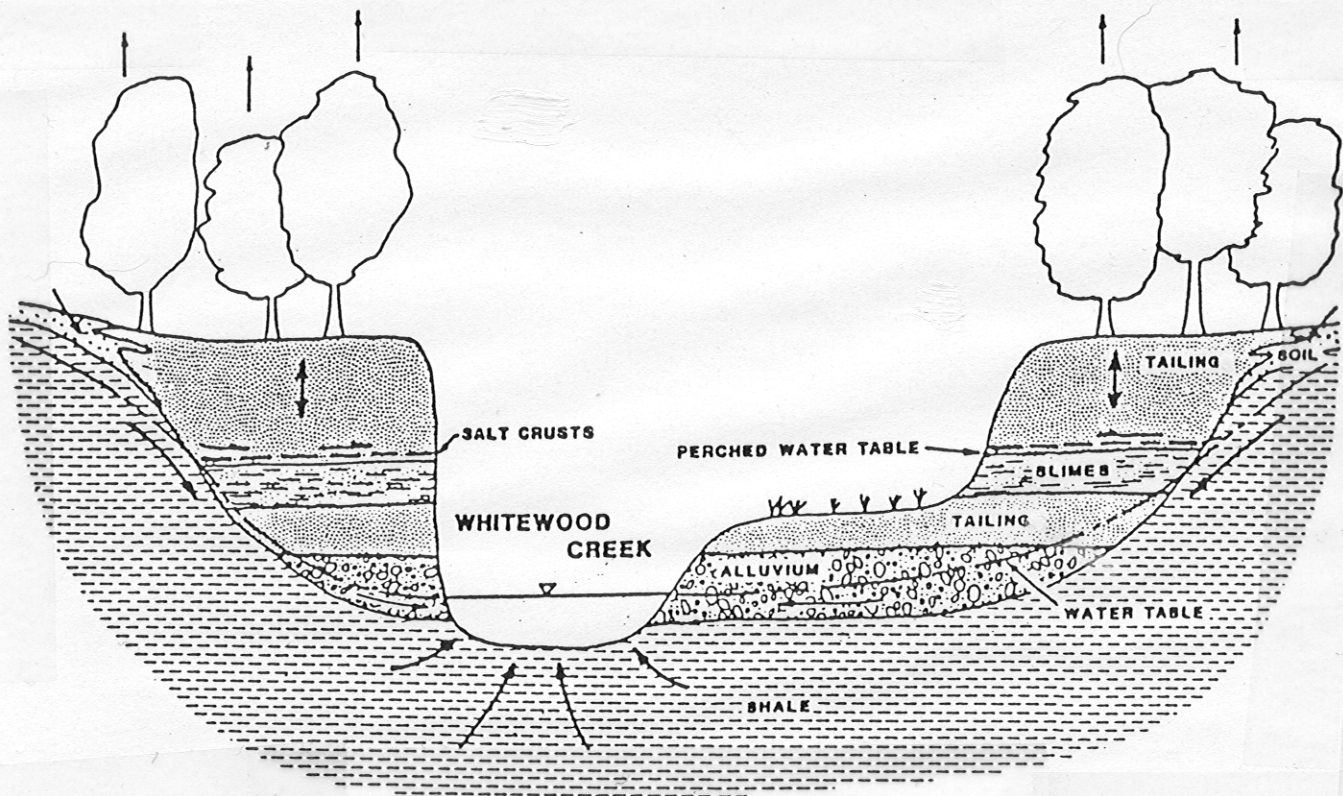
Discharge from Water Treatment

Figure 2-2 (cont.) Gold Run Creek

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

**Figure 2-3 Schematic Representation of the Geology and Water-Circulation Pathways in the Whitewood Creek Valley**

*Ecological Risk Assessment  
Whitewood Creek, Lead, South Dakota*



Source: Cherry et al., 1986 (Part 2 of 3, Figure 4)



Figure 2-4. Tailing Deposits along Whitewood Creek

*Ecological Risk Assessment*

*Whitewood Creek, Lead, South Dakota*

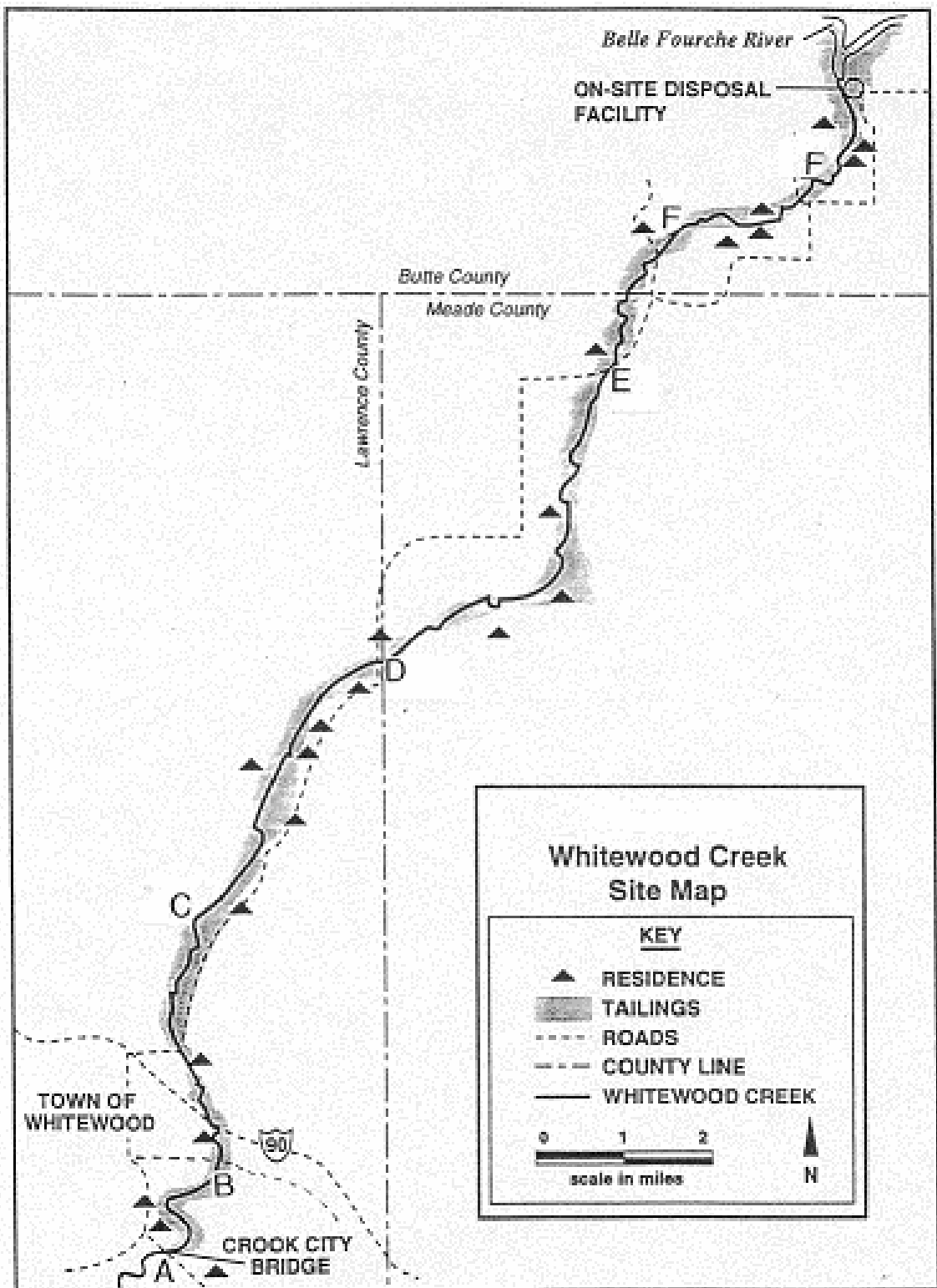


Figure 2-5. Photographs of Whitewood Creek

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*



Location A: Crook City Bridge, Facing Upriver



Location A: Crook City Bridge, Facing Downriver

Figure 2-5 (cont.) Photographs of Whitewood Creek

*Ecological Risk Assessment*

*Whitewood Creek, Lead, South Dakota*



Location B: Facing Upriver



Location B: Facing Downriver

Figure 2-5 (cont.) Photographs of Whitewood Creek

*Ecological Risk Assessment  
Whitewood Creek, Lead, South Dakota*



Location C: Facing Upriver



Location C: Facing Downriver

Figure 2-5 (cont.) Photographs of Whitewood Creek

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*



Location D: Facing Upriver



Location D: Facing Downriver

Figure 2-5 (cont.) Photographs of Whitewood Creek

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*



Location E: Facing Upriver



Location E: Facing Downriver

Figure 2-5 (cont.) Photographs of Whitewood Creek

*Ecological Risk Assessment*

*Whitewood Creek, Lead, South Dakota*



Location F1: Facing Upriver



Location F1: Facing Downriver

Figure 2-5 (cont.) Photographs of Whitewood Creek

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*



Location F2: Facing Upriver

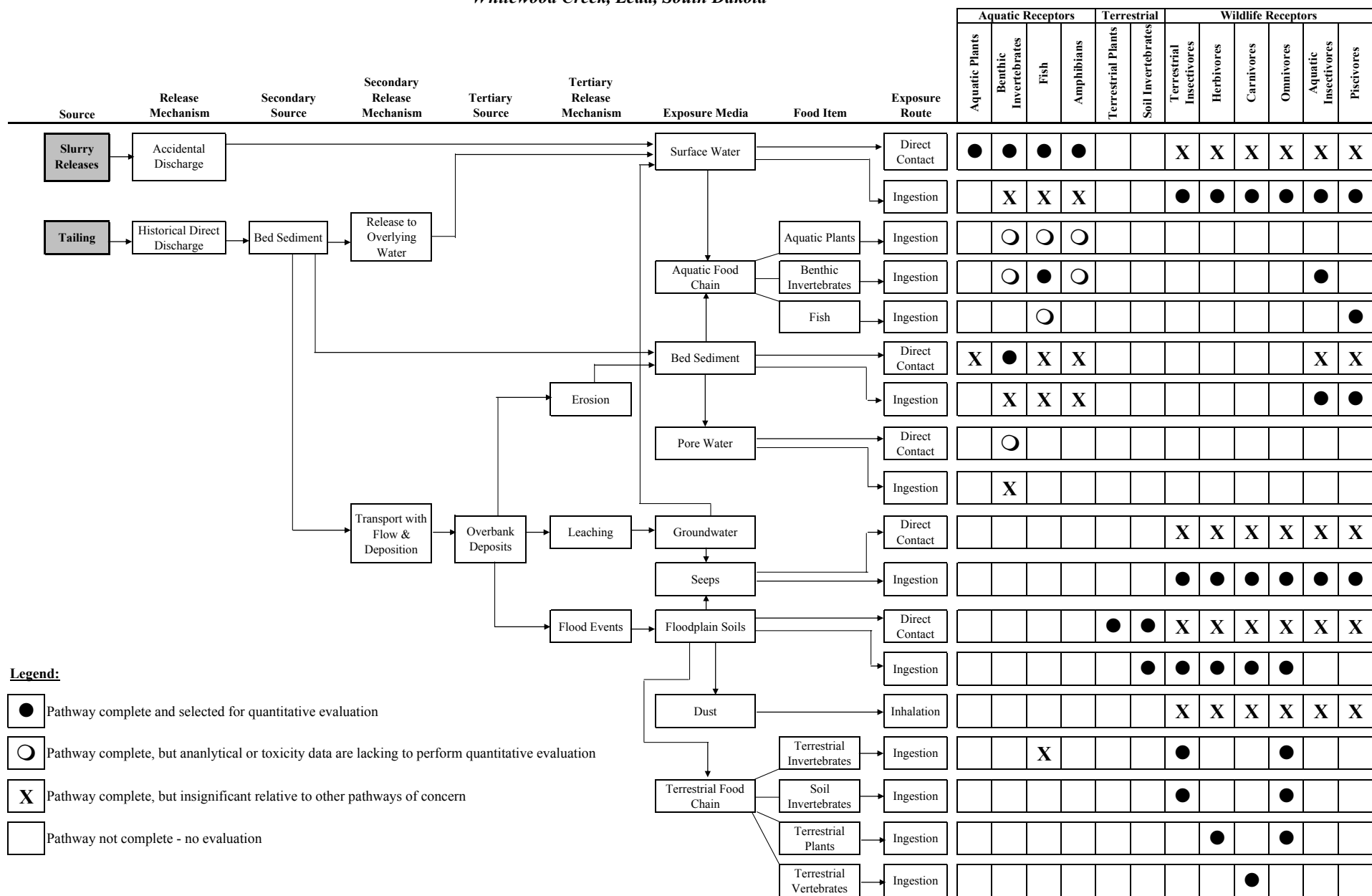


Location F2: Facing Downriver

Figure 2-5 (cont.) Photographs of Whitewood Creek

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

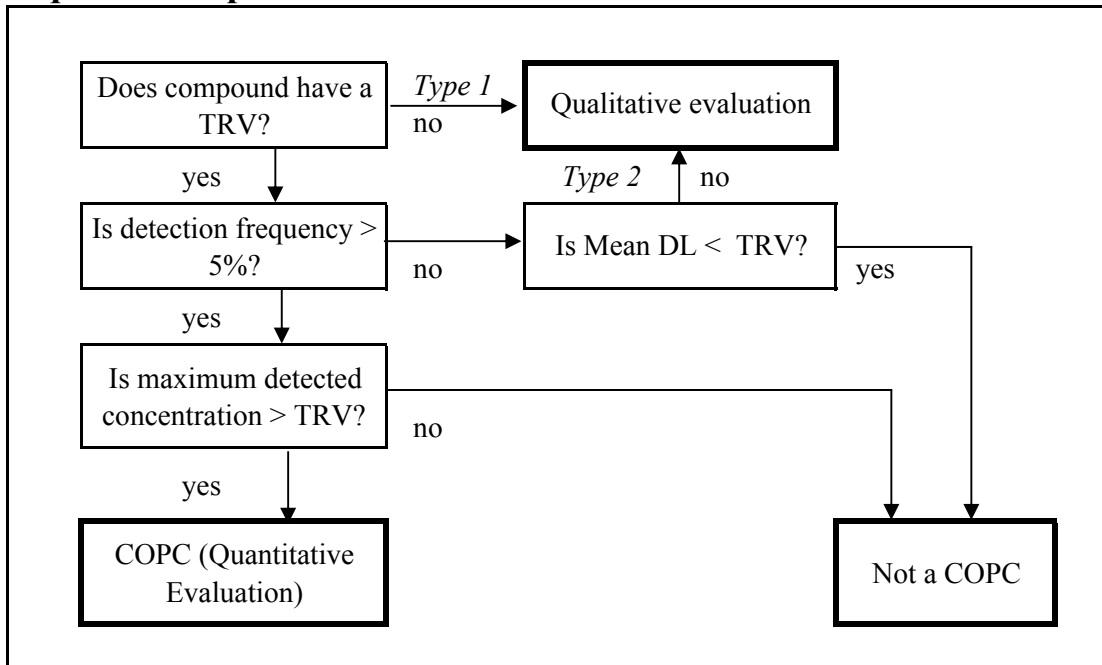
**Figure 3-1**  
**Ecological Site Conceptual Model**  
*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*



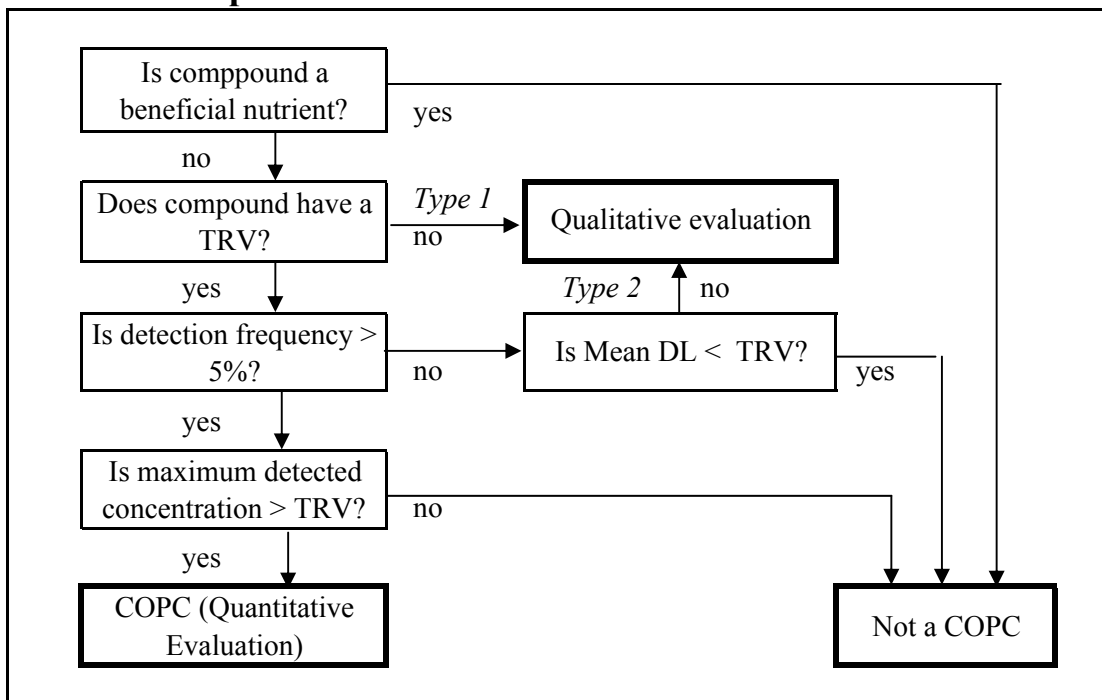
**Figure 3-2 COPC Selection Procedure**

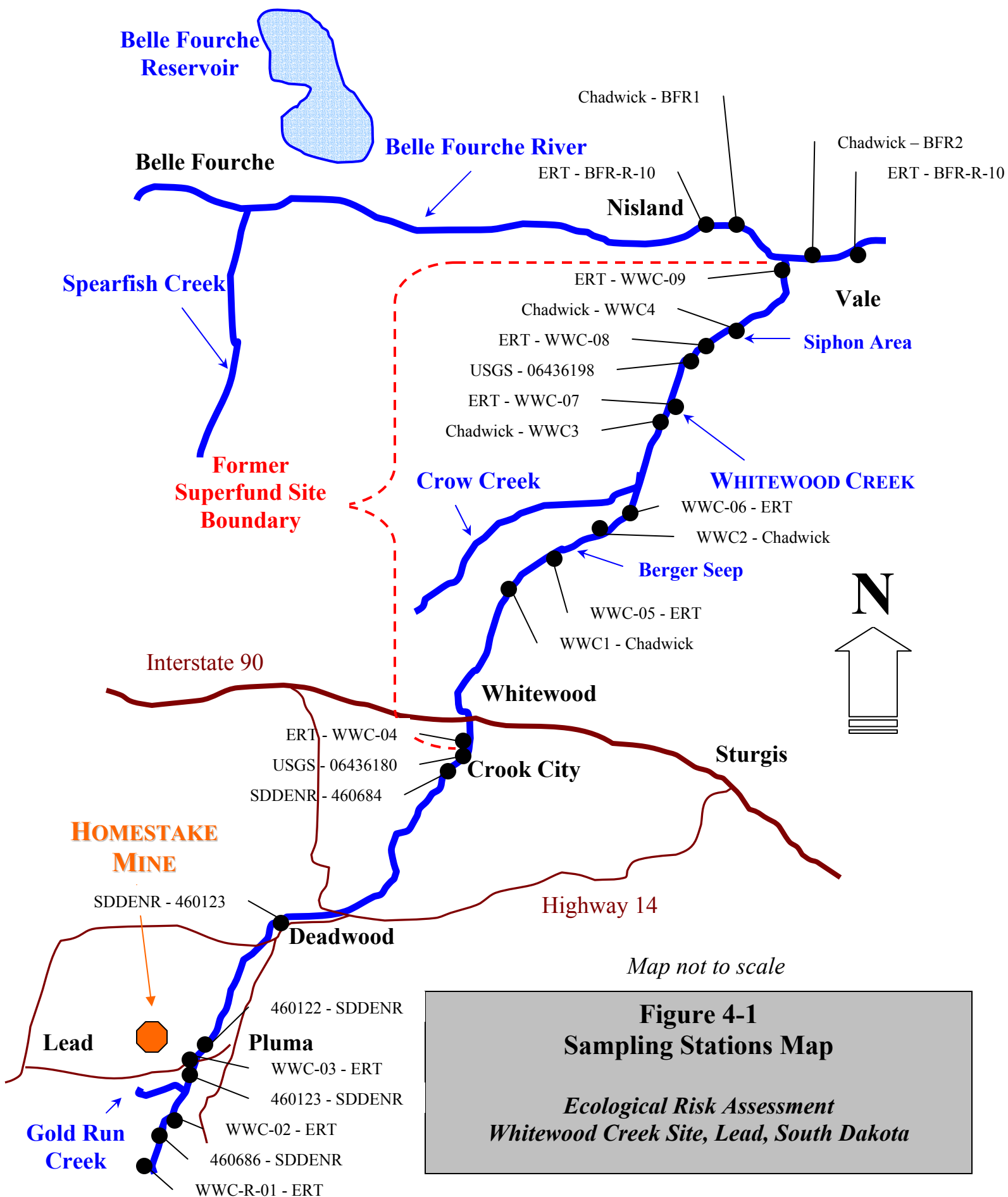
*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

**Aquatic Receptors**



**Wildlife Receptors**





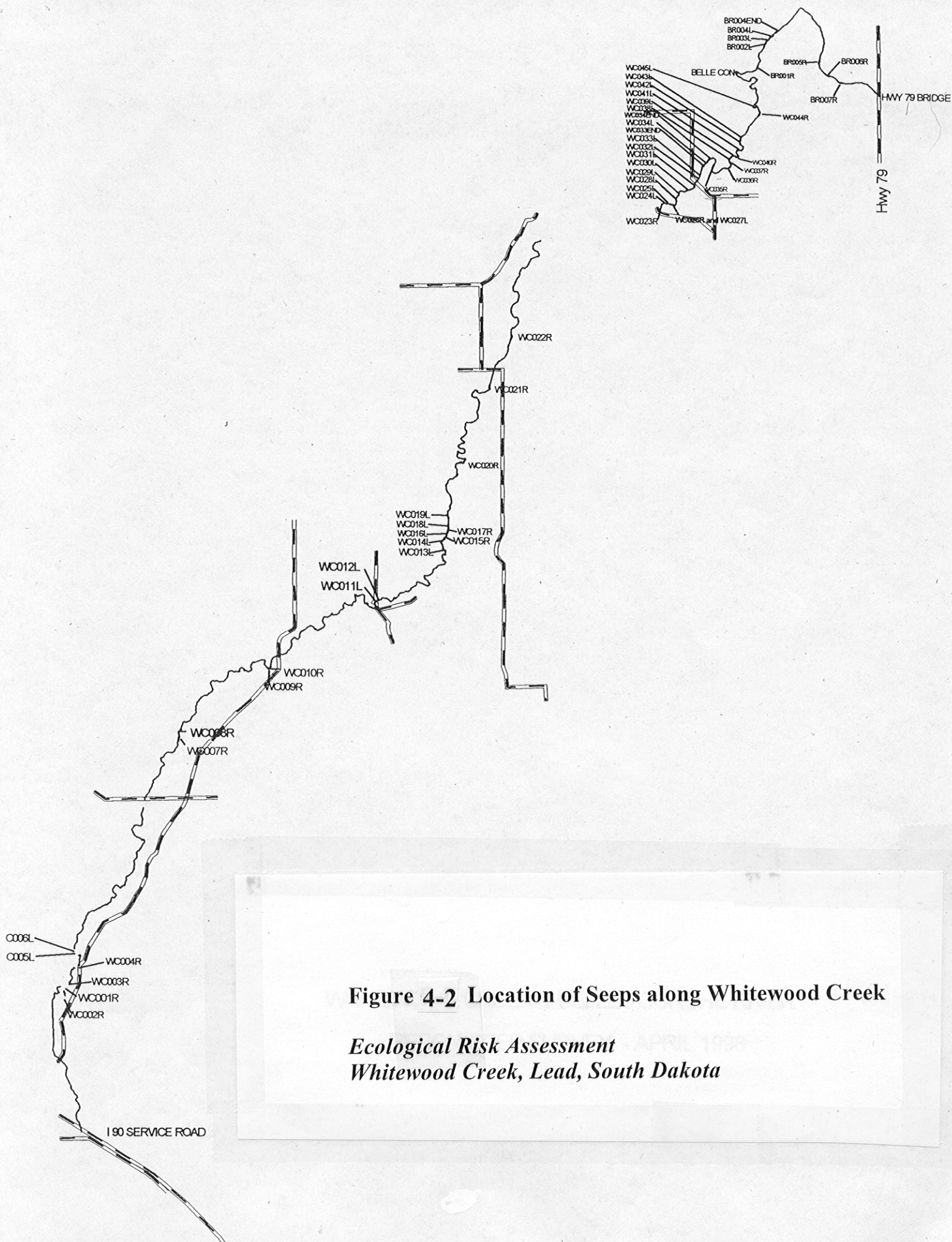
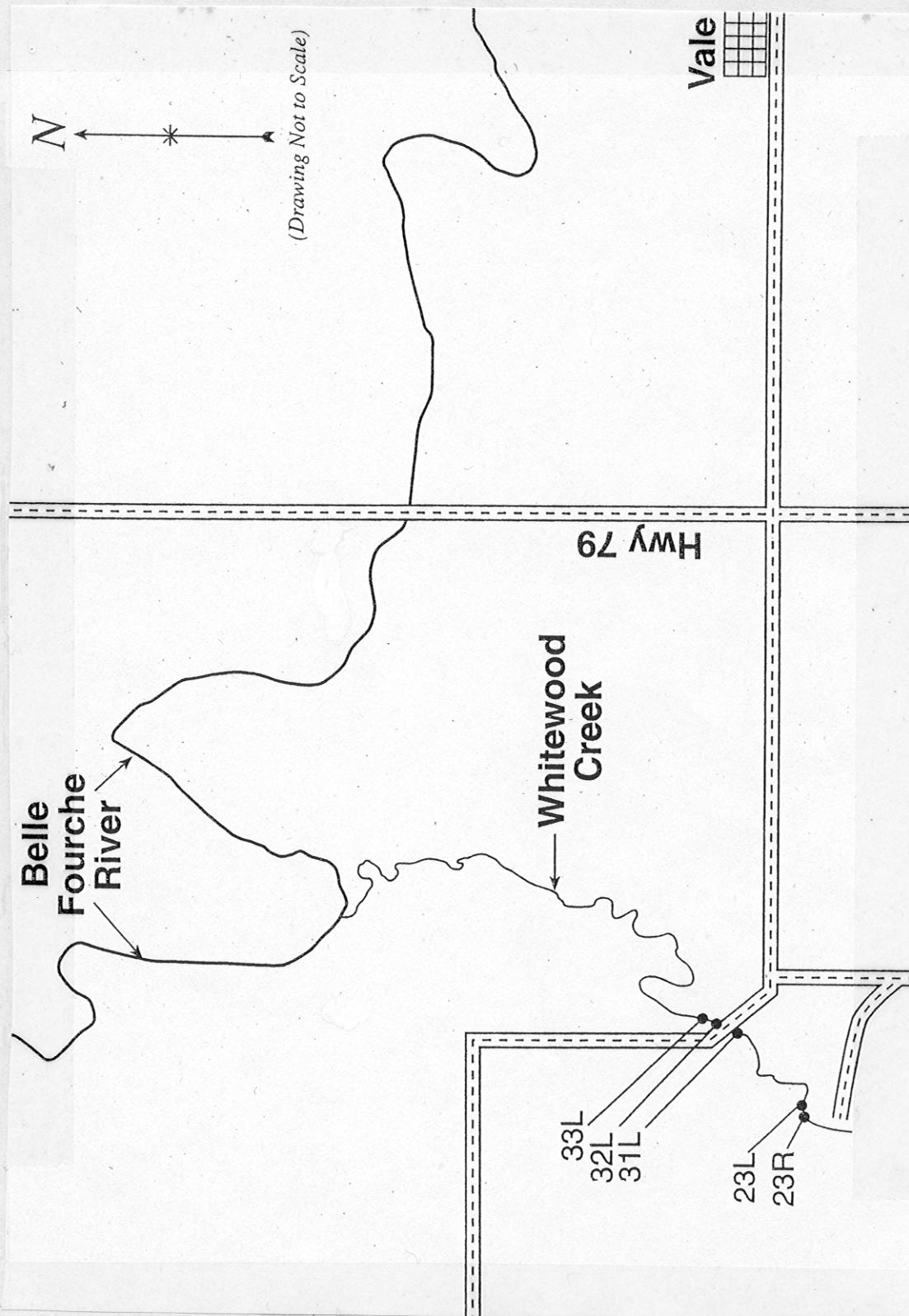


Figure 4-3

Location of Seep Samples Collected for Toxicity Testing with the Fathead Minnow

*Ecological Risk Assessment for Whitewood Creek, Lead, South Dakota*

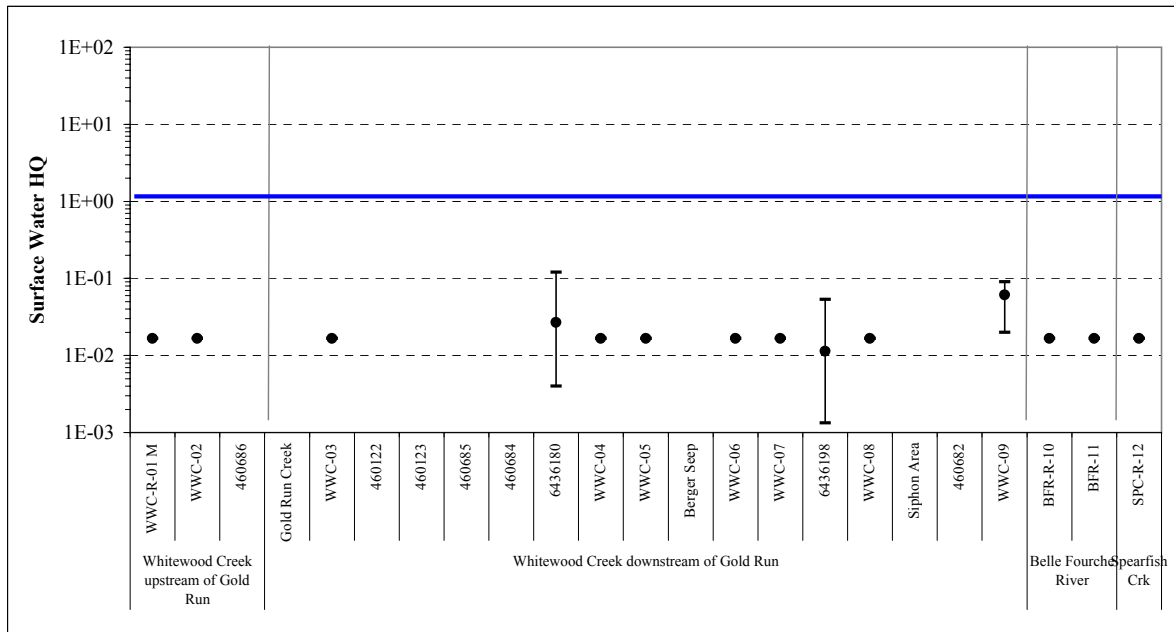


**Figure 6-1a**  
**Surface Water HQs for Aquatic Receptors Based on National AWQC Values**

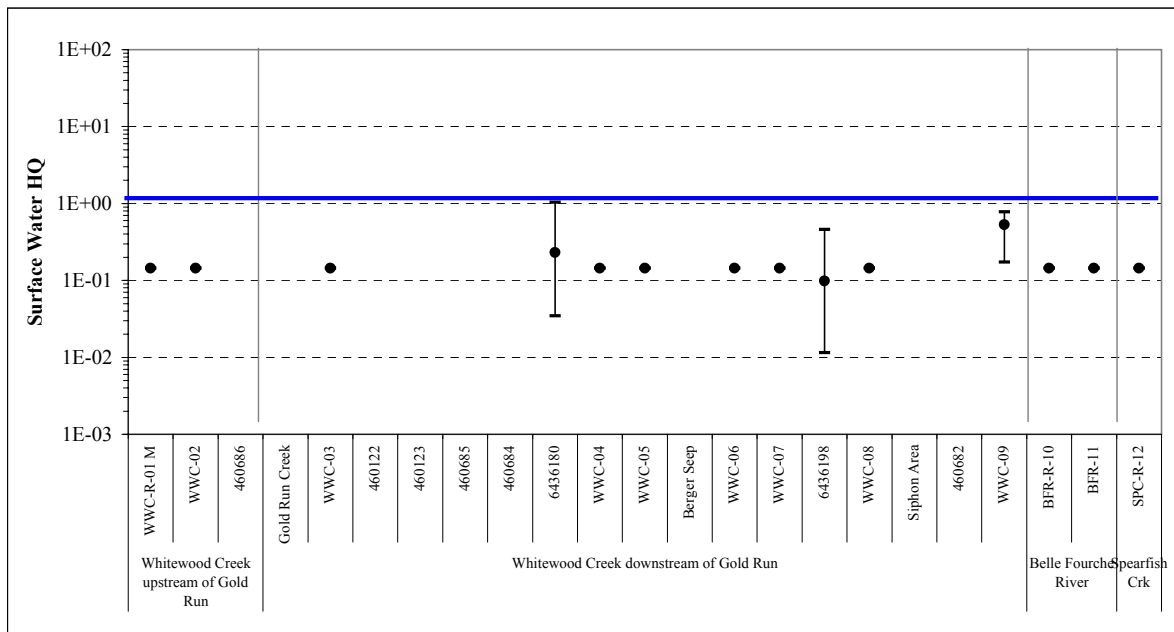
*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

**ALUMINUM**

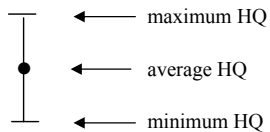
*Based on the Acute AWQC*



*Based on the Chronic AWQC*



**LEGEND:**

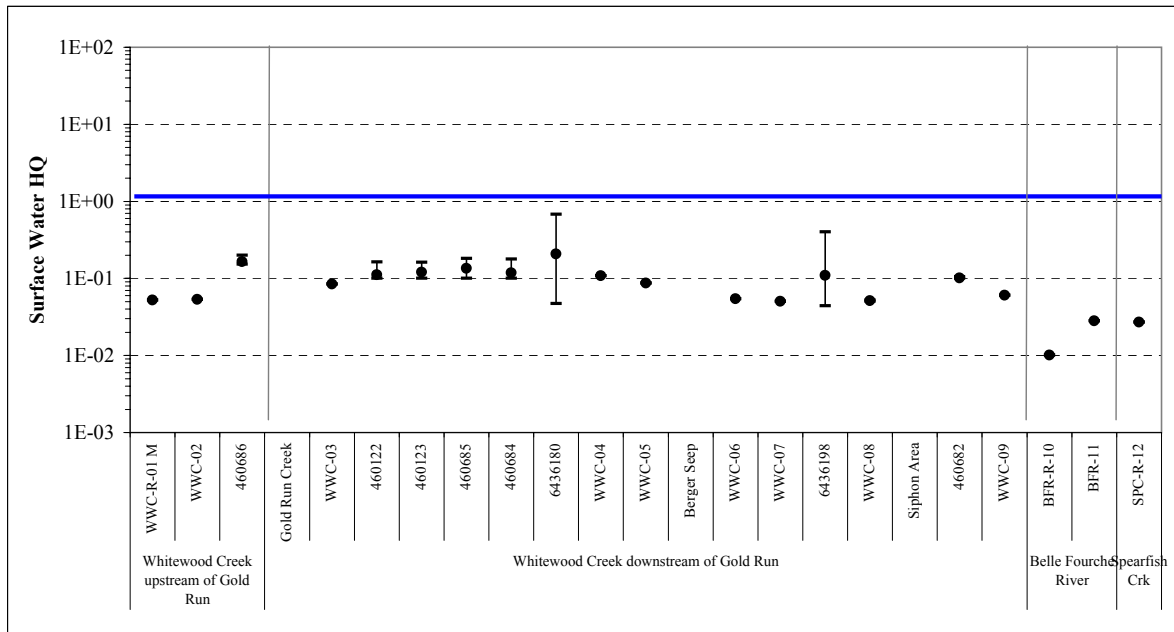


**Figure 6-1b**  
**Surface Water HQs for Aquatic Receptors Based on National AWQC Values**

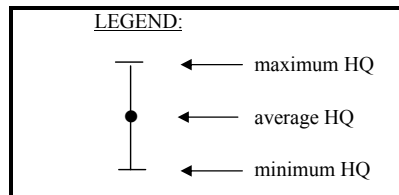
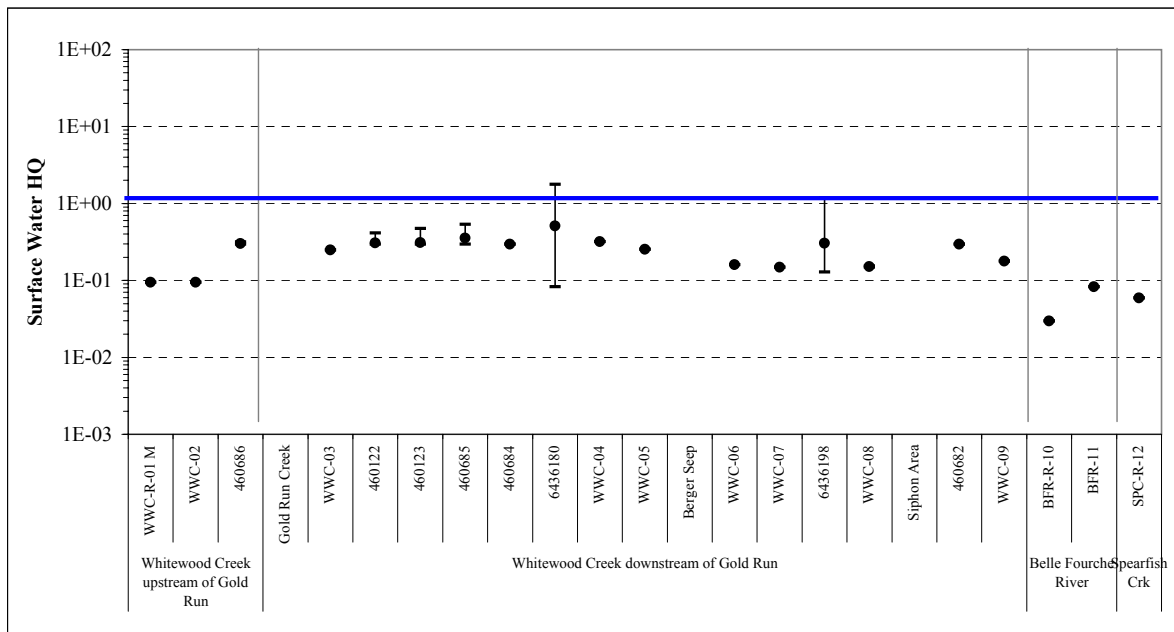
*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

**COPPER**

*Based on the Acute AWQC*



*Based on the Chronic AWQC*

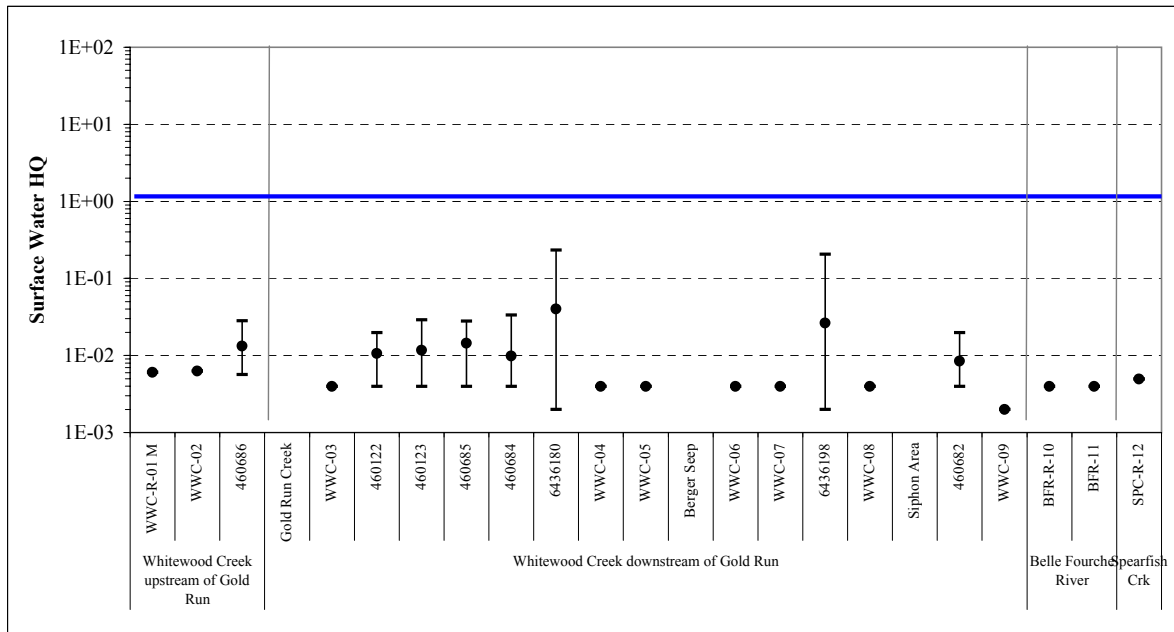


**Figure 6-1c**  
**Surface Water HQs for Aquatic Receptors Based on National AWQC Values**

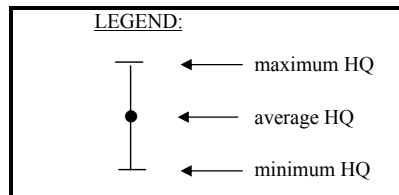
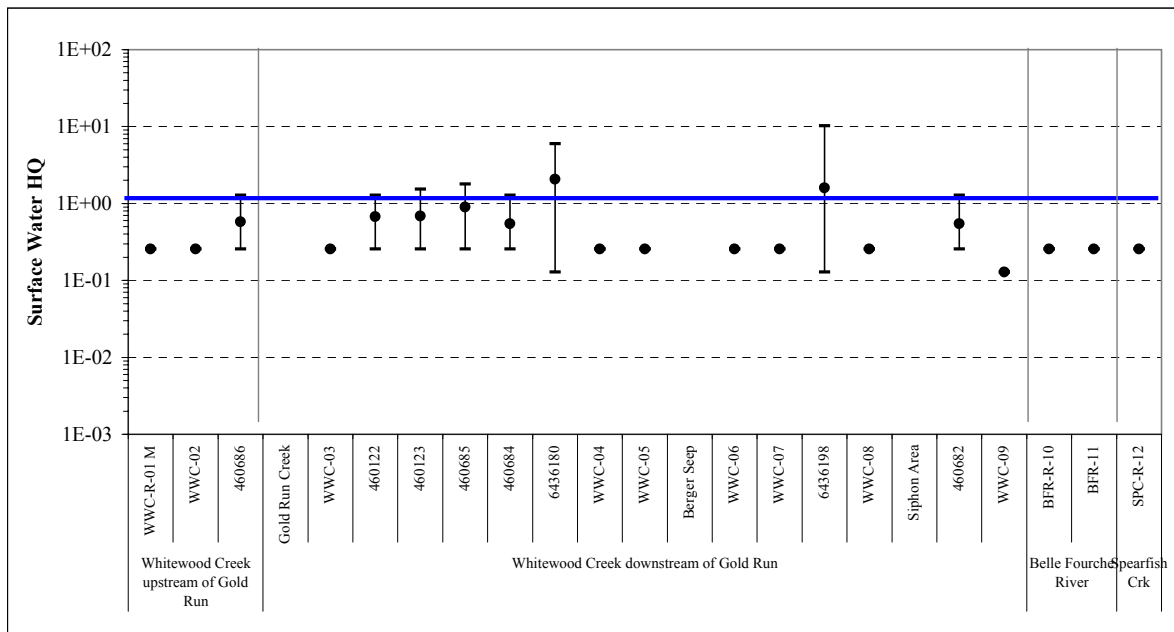
*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

**LEAD**

*Based on the Acute AWQC*



*Based on the Chronic AWQC*

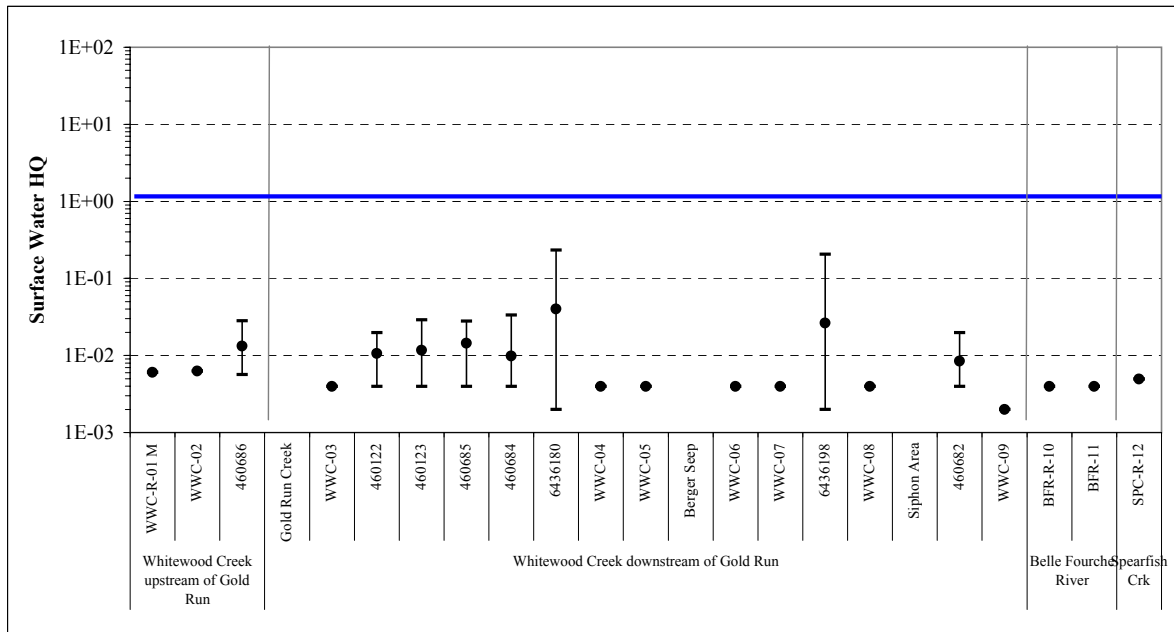


**Figure 6-1c**  
**Surface Water HQs for Aquatic Receptors Based on National AWQC Values**

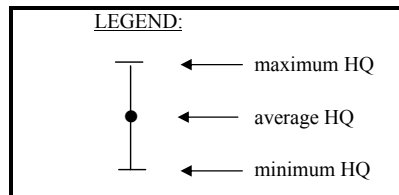
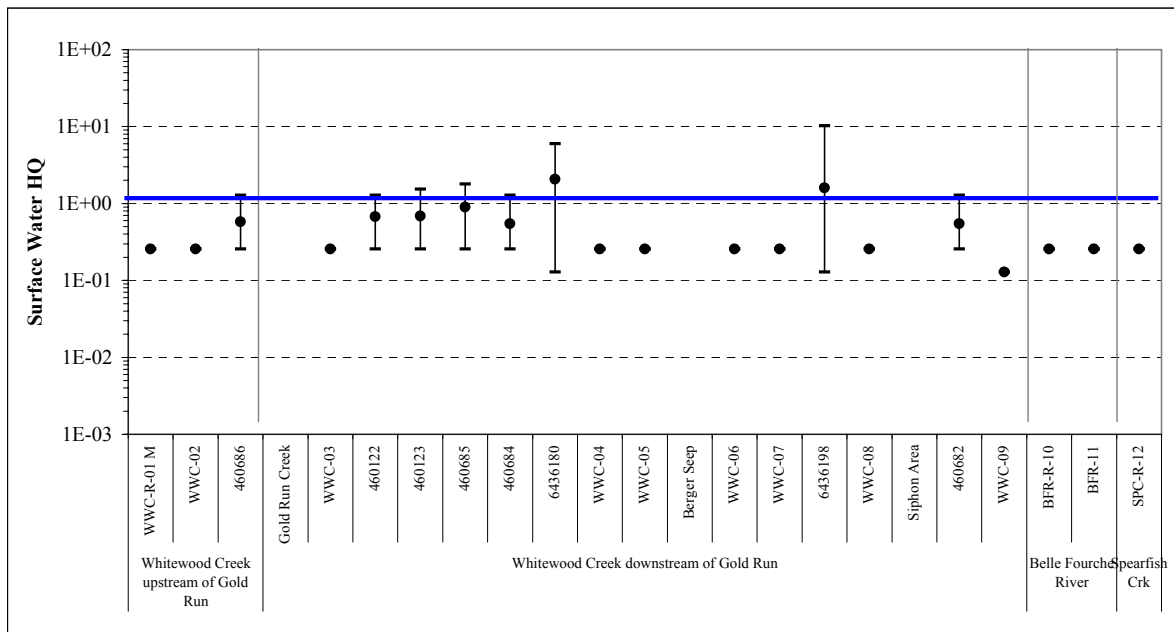
*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

**LEAD**

*Based on the Acute AWQC*



*Based on the Chronic AWQC*

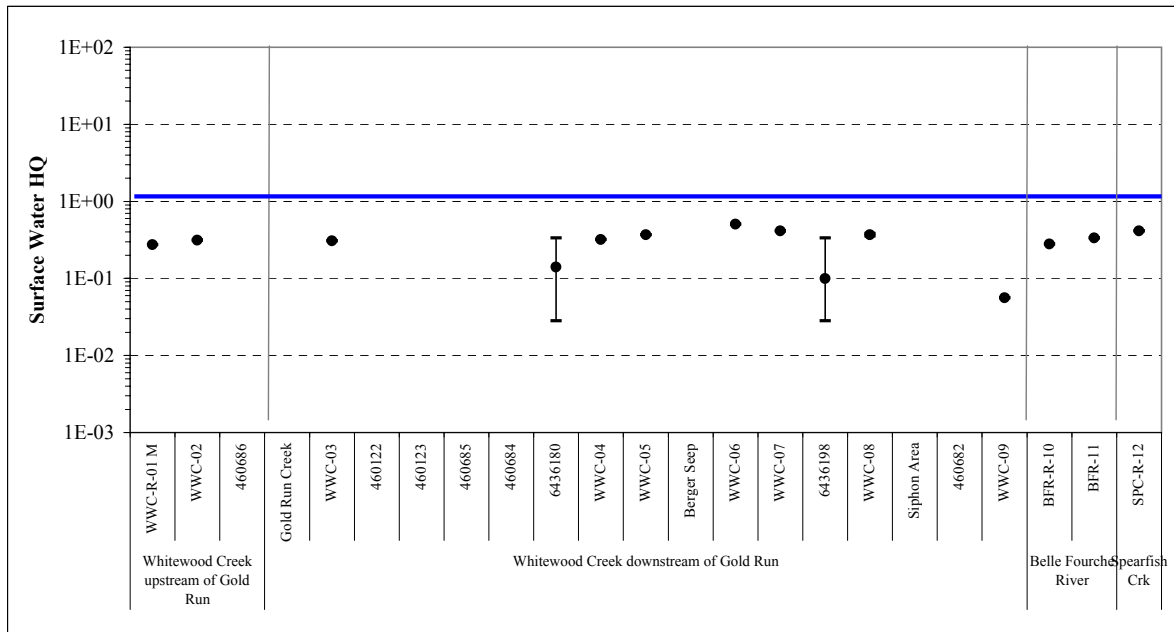


**Figure 6-1d**  
**Surface Water HQs for Aquatic Receptors Based on National AWQC Values**

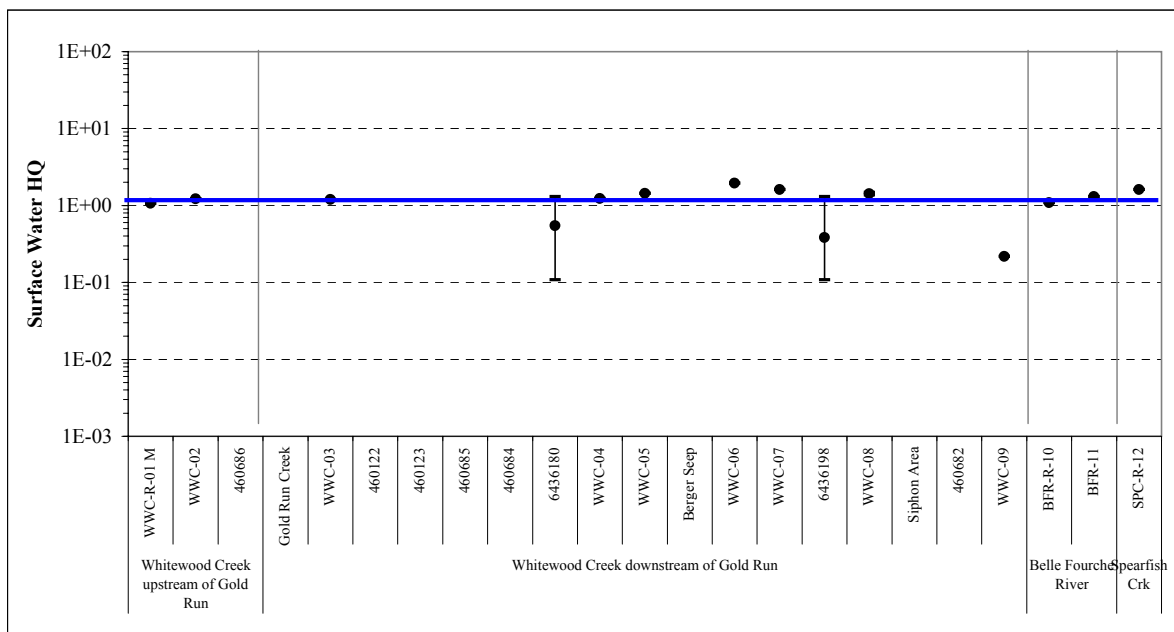
*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

**SELENIUM**

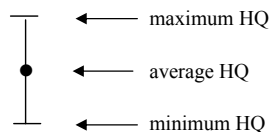
*Based on the Acute AWQC*



*Based on the Chronic AWQC*



**LEGEND:**

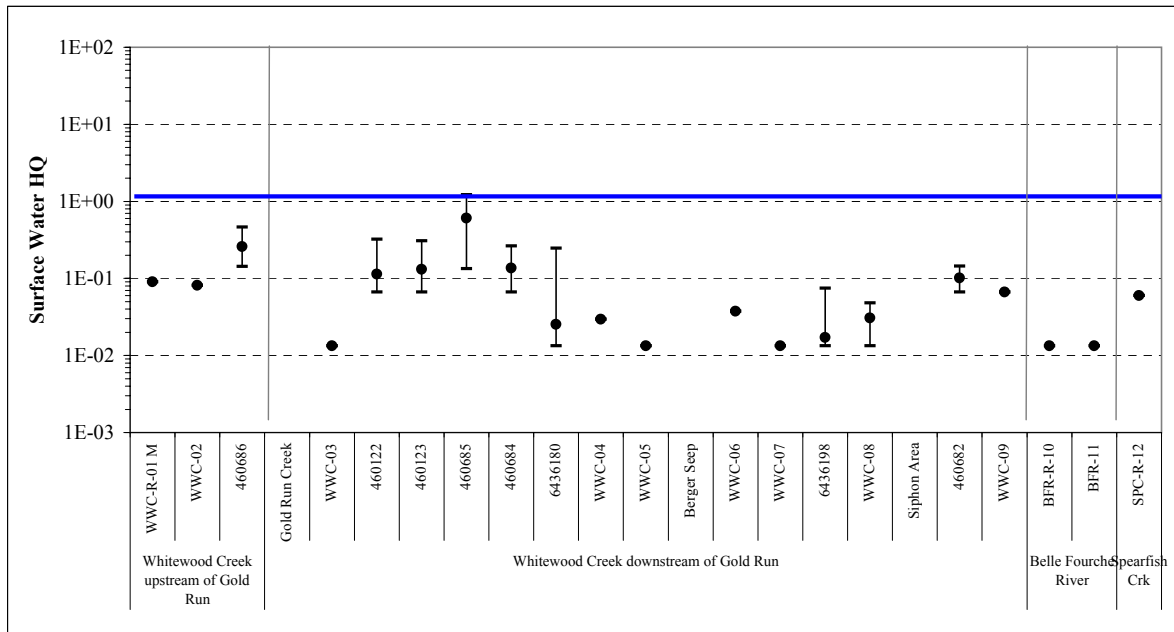


**Figure 6-1e**  
**Surface Water HQs for Aquatic Receptors Based on National AWQC Values**

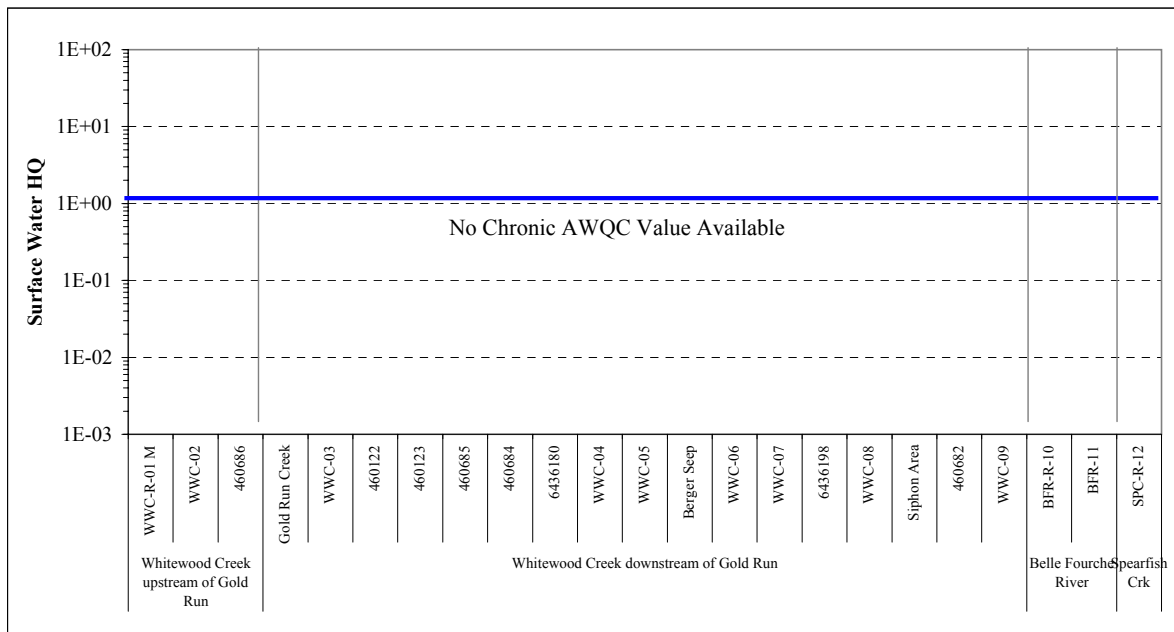
*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

**SILVER**

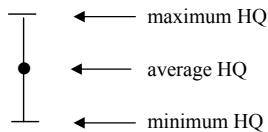
*Based on the Acute AWQC*



*Based on the Chronic AWQC*



**LEGEND:**

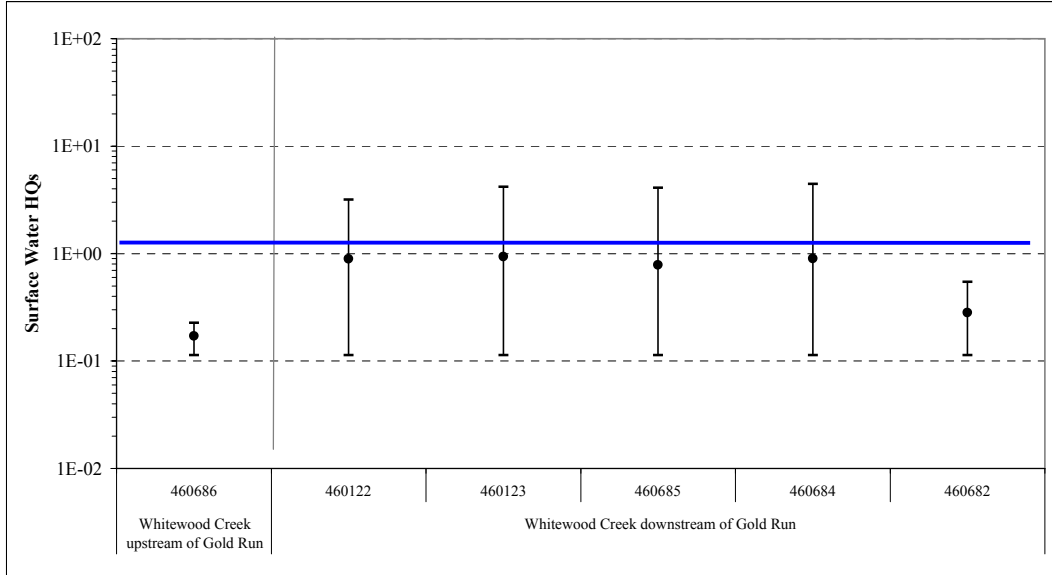


**Figure 6-1f**  
**Surface Water HQs for Aquatic Receptors Based on National AWQC Values**

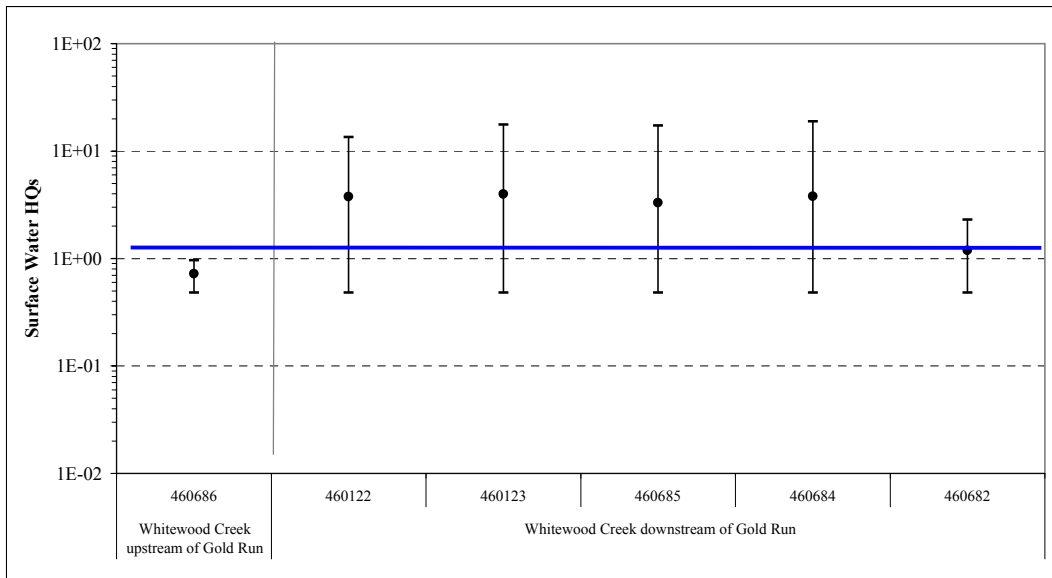
*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

**WAD CYANIDE**

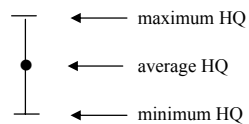
*Based on the Acute AWQC*



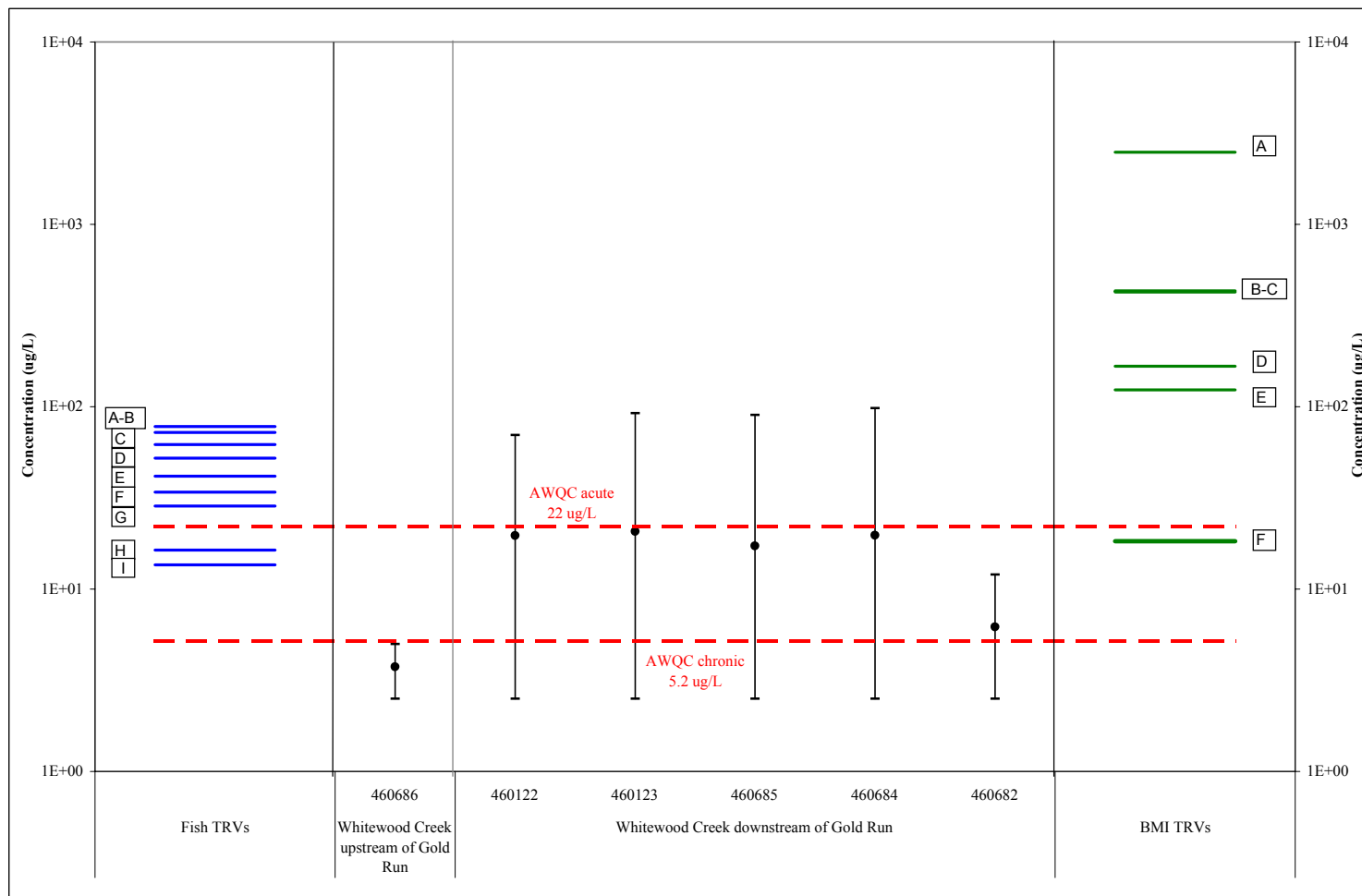
*Based on the Chronic AWQC*



LEGEND:



**Figure 6-2**  
**Comparison of WAD Cyanide Concentrations with Acute and Chronic AWQC Toxicity Values for Fish and Benthic Invertebrates**



FISH TRVs (ug/L)		
A	78	Brook trout (adult), acute
B	72	Fathead minnow (juv), acute
C	62	Bluegill (juv), acute
D	52	Fathead minnow (fry), acute
E	42	Brook trout (fry/juv), acute
F	34	Brook trout, chronic
G	29	Rainbow trout (juv), acute
H	16	Fathead minnow, chronic
I	14	Bluegill, chronic

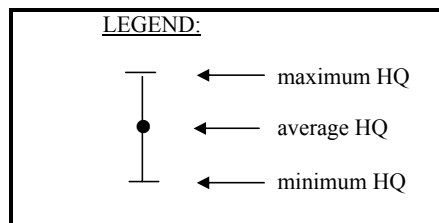
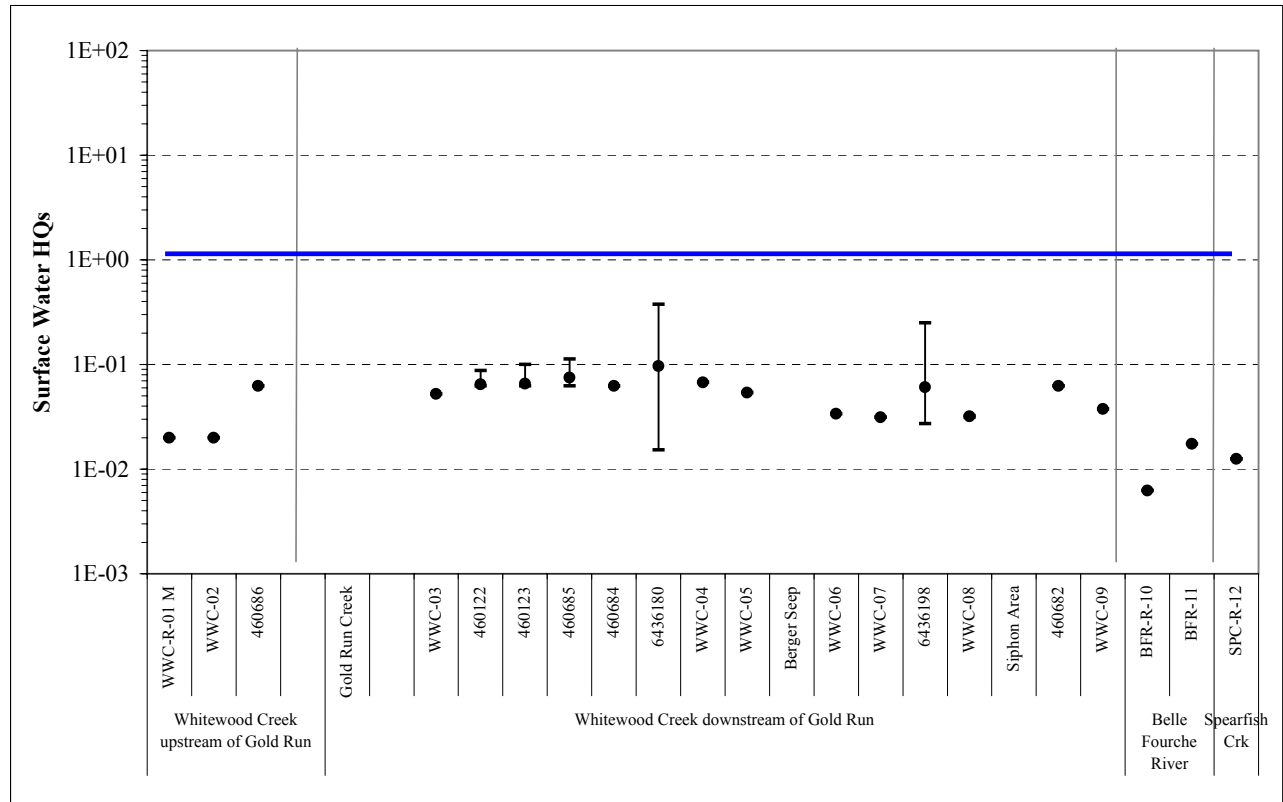
LEGEND	
	Maximum Concentration
	Average Concentration
	Minimum Concentration

BMI TRVs (ug/L)		
A	2,490	Midge, acute
B	432	Snail, acute
C	426	Stonefly, acute
D	167	Amphipod, acute
E	124	Daphnia sp., acute
F	18	Amphipod, chronic

**Figure 6-3a**  
**Surface Water HQs for Aquatic Receptors Based on Site-Specific Standards**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

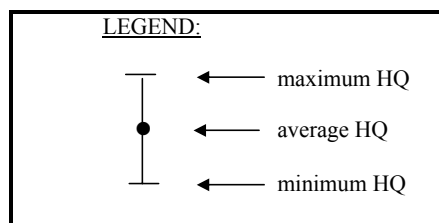
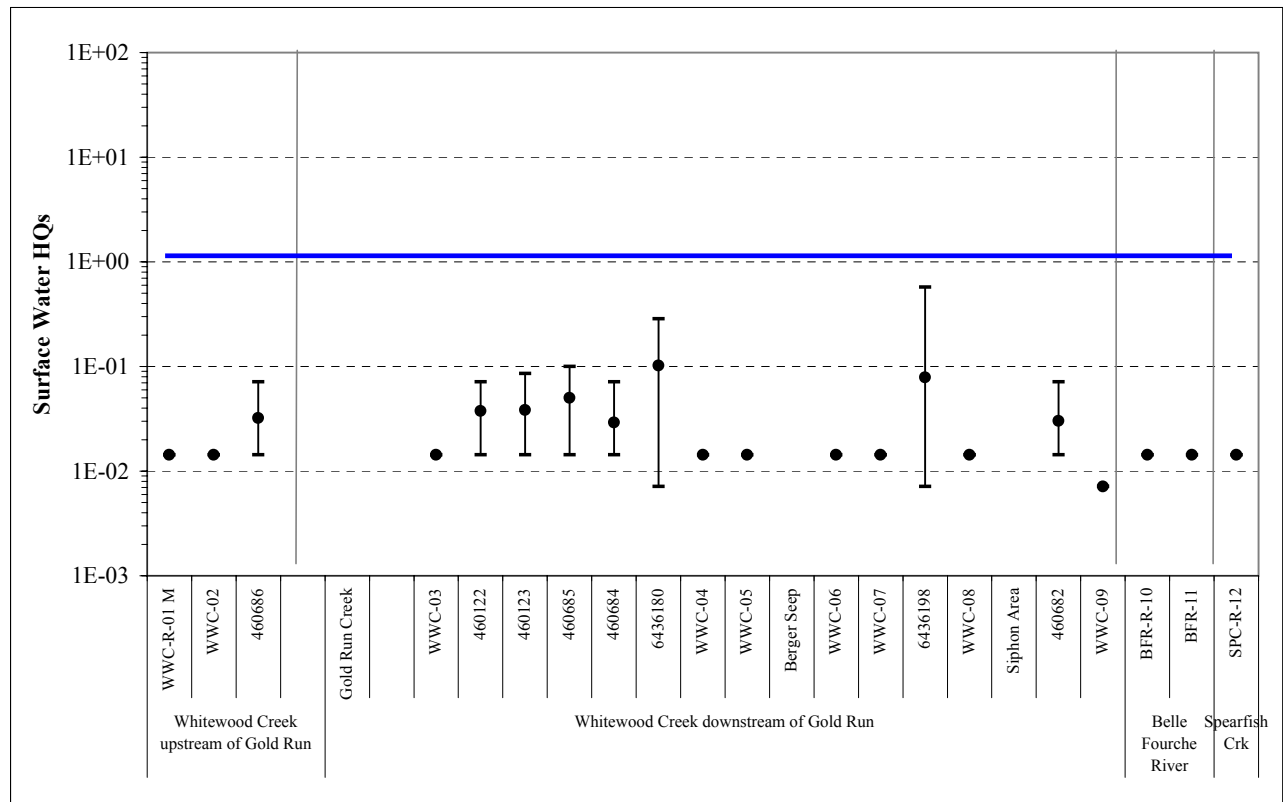
**COPPER**



**Figure 6-3b**  
**Surface Water HQs for Aquatic Receptors Based on Site-Specific Standards**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

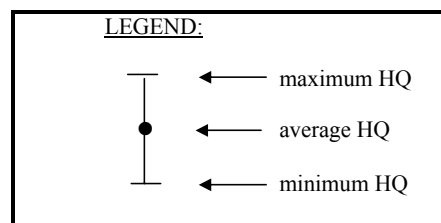
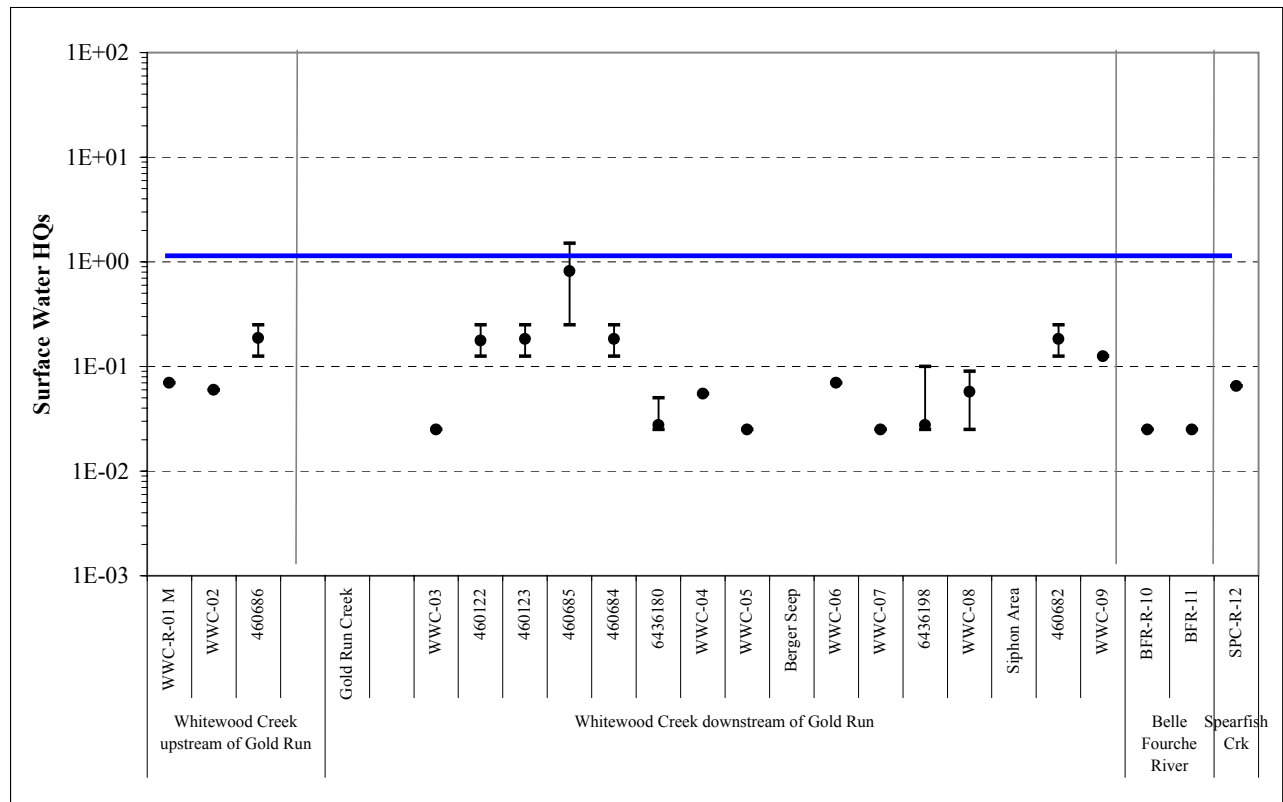
**LEAD**



**Figure 6-3c**  
**Surface Water HQs for Aquatic Receptors Based on Site-Specific Standards**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

**SILVER**



**Figure 6-3d**  
**Surface Water HQs for Aquatic Receptors Based on Site-Specific Standards**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

**WAD CYANIDE**

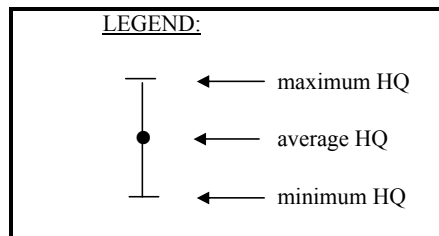
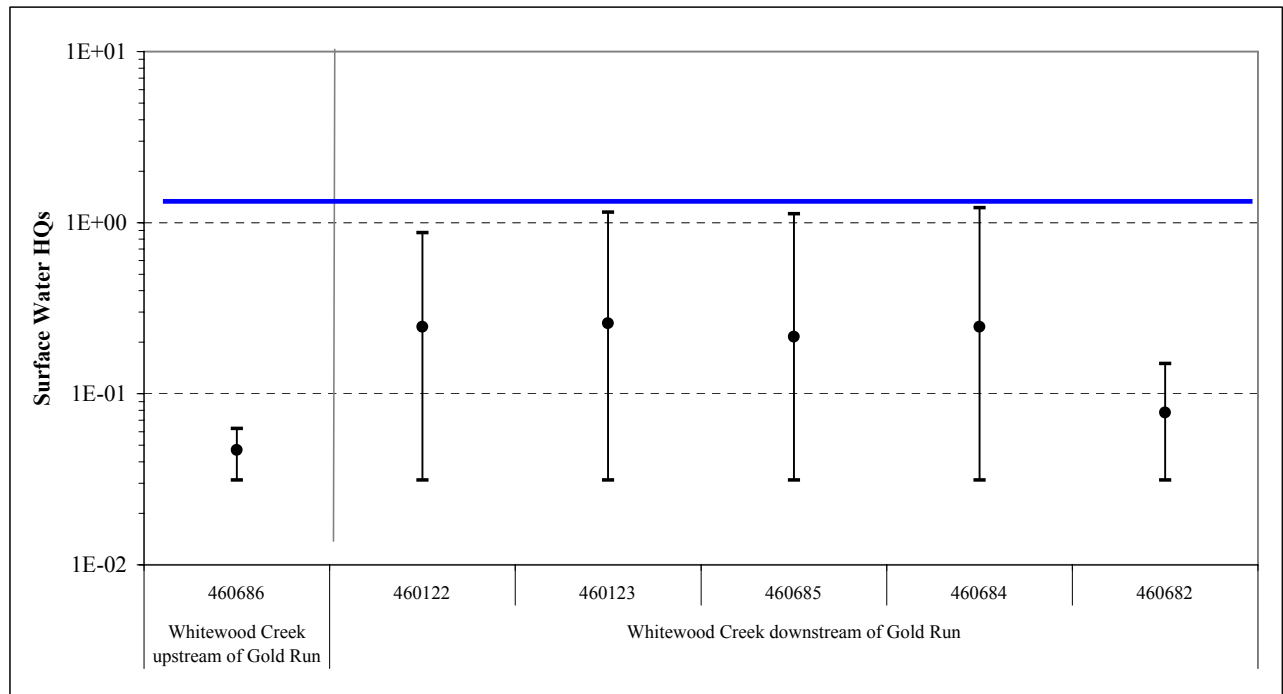
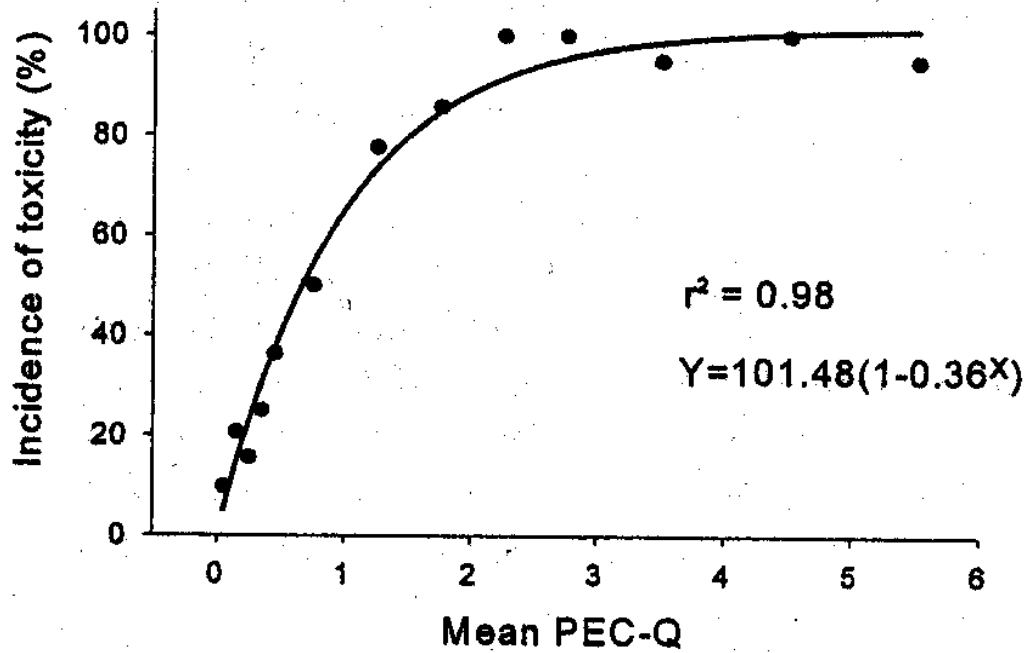


Figure 6-4

Relationship Between the Mean PEC Quotient and the Incidence of Toxicity in Freshwater Sediments

*Ecological Risk Assessment  
Whitewood Creek, Lead, South Dakota*

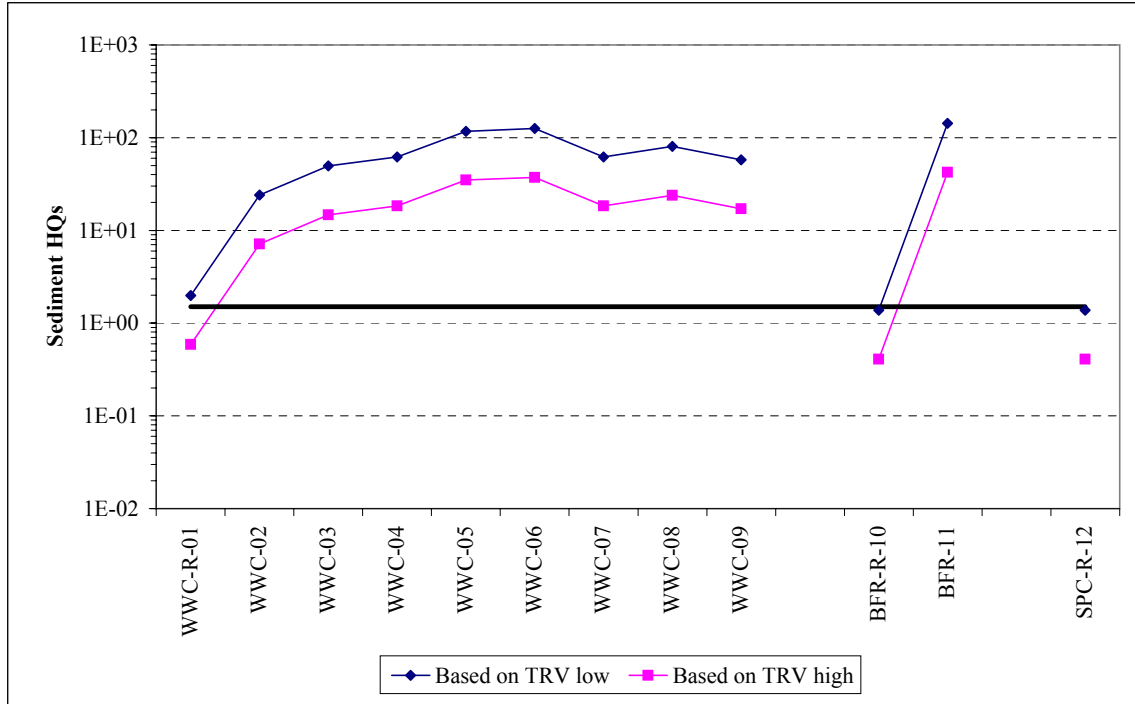


Source: MacDonald et al., 2000

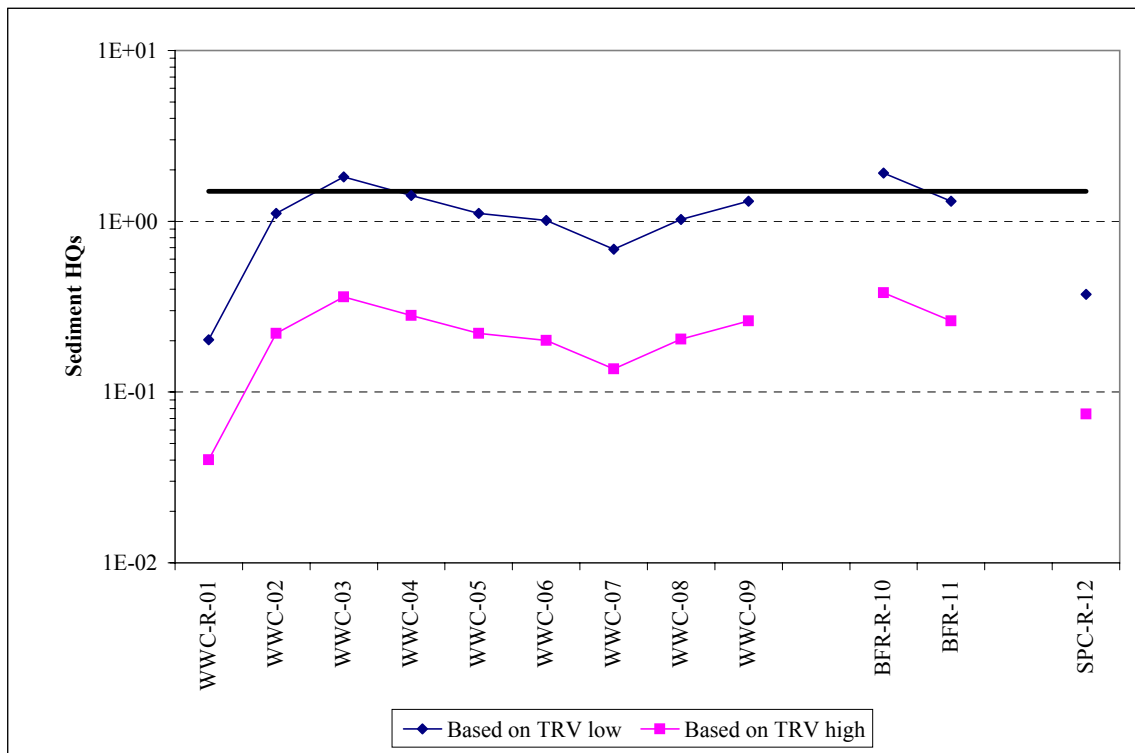
**Figure 6-5**  
**Summary of Sediment HQs for Benthic Macroinvertebrates**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

**ARSENIC**



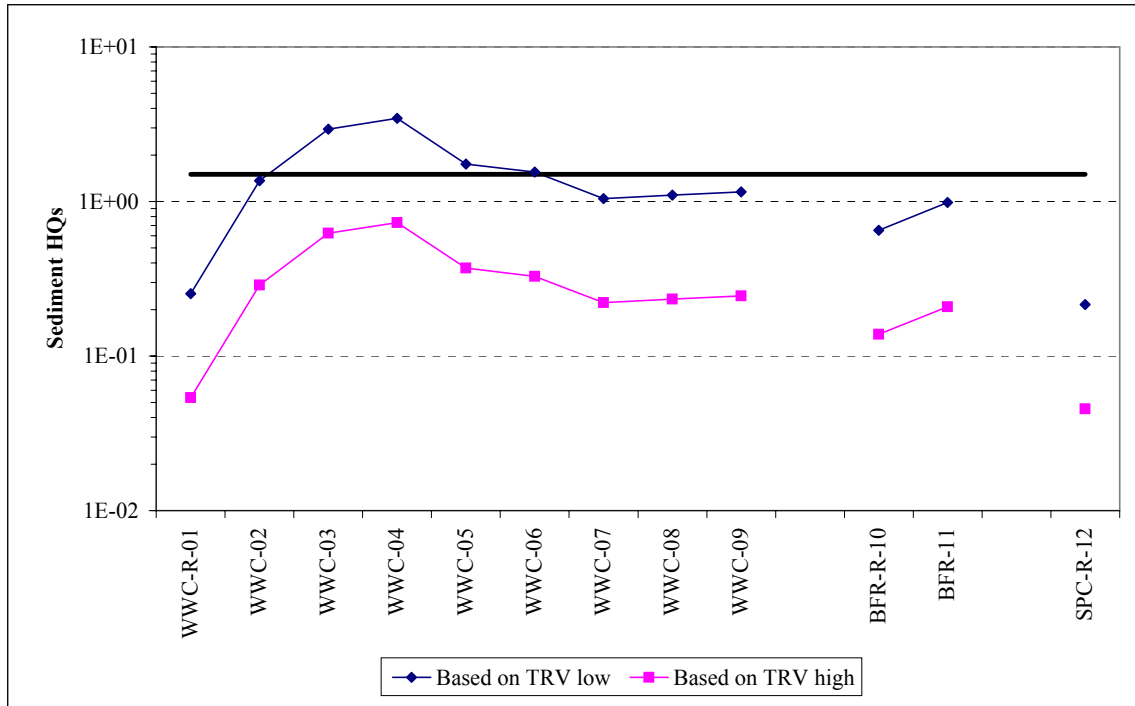
**CADMIUM**



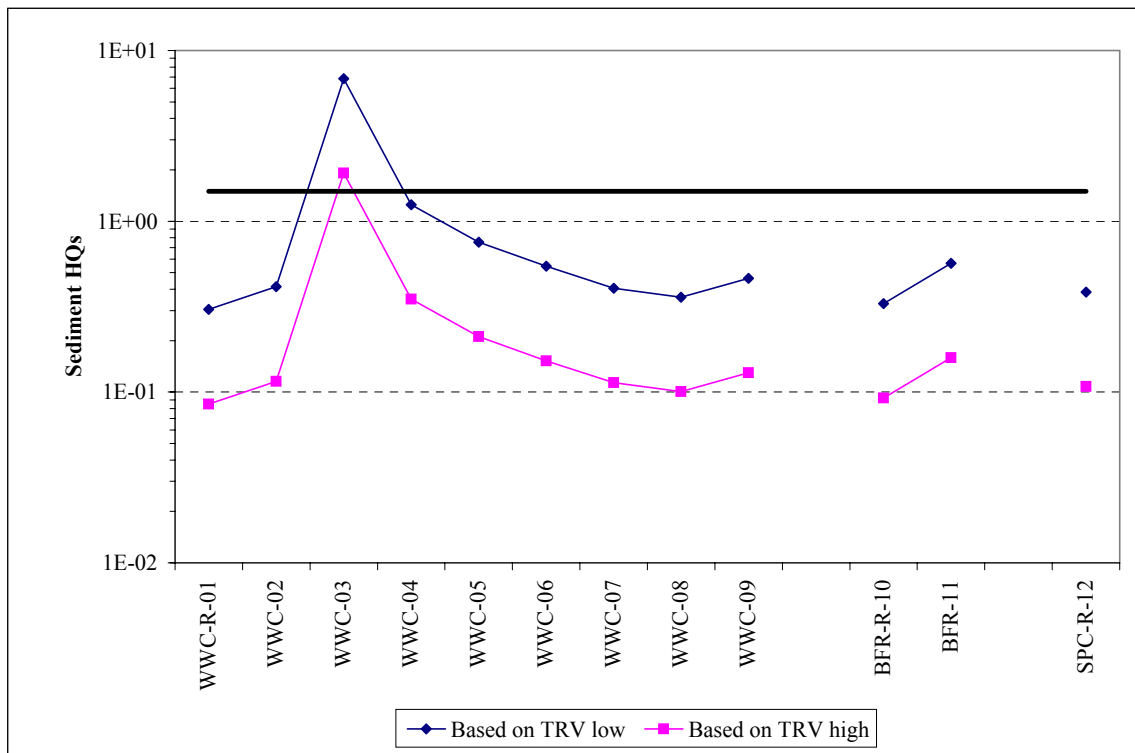
**Figure 6-5**  
**Summary of Sediment HQs for Benthic Macroinvertebrates**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

**COPPER**



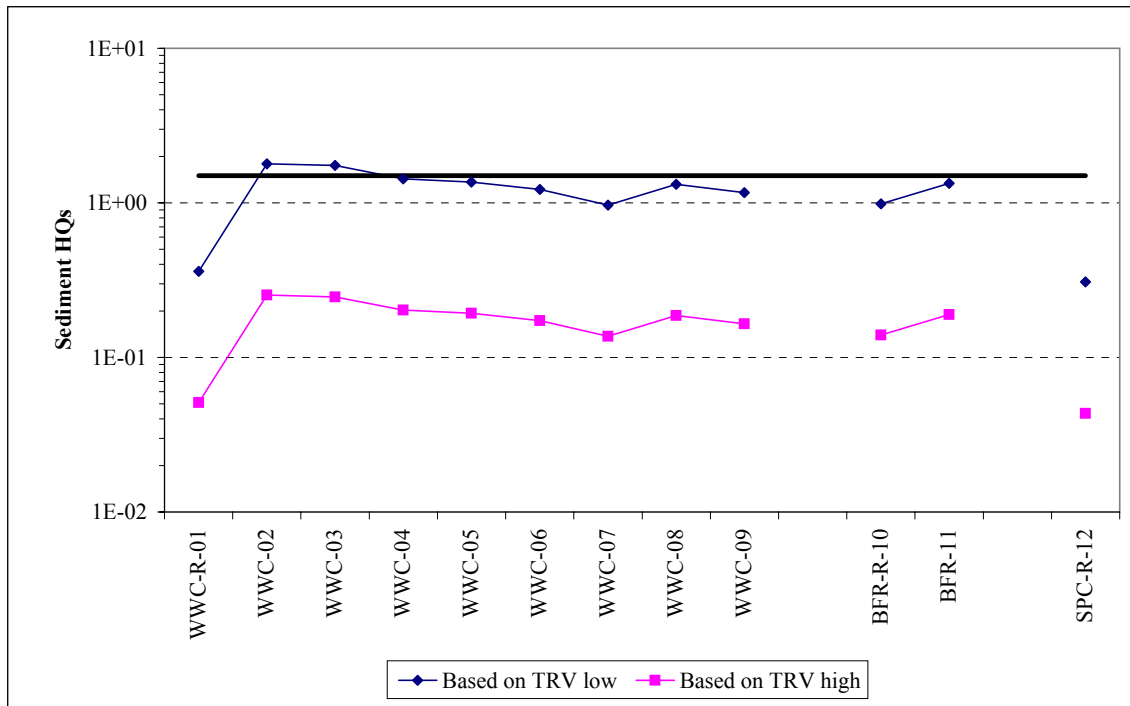
**LEAD**



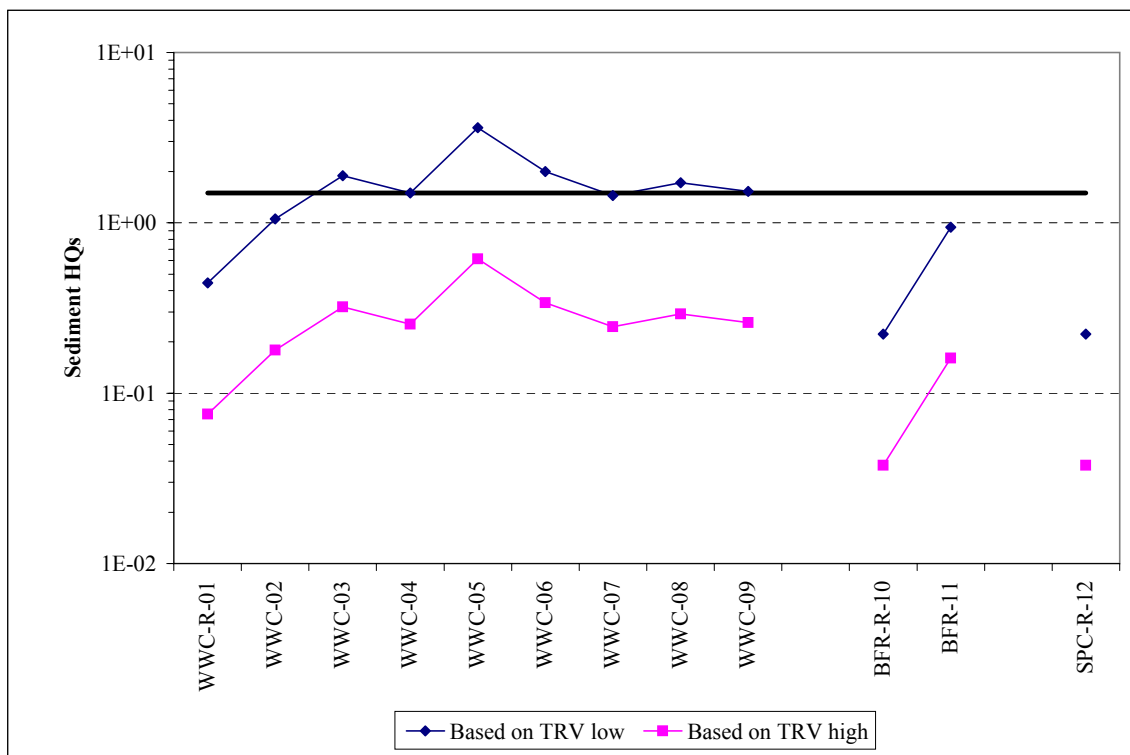
**Figure 6-5**  
**Summary of Sediment HQs for Benthic Macroinvertebrates**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

**MANGANESE**



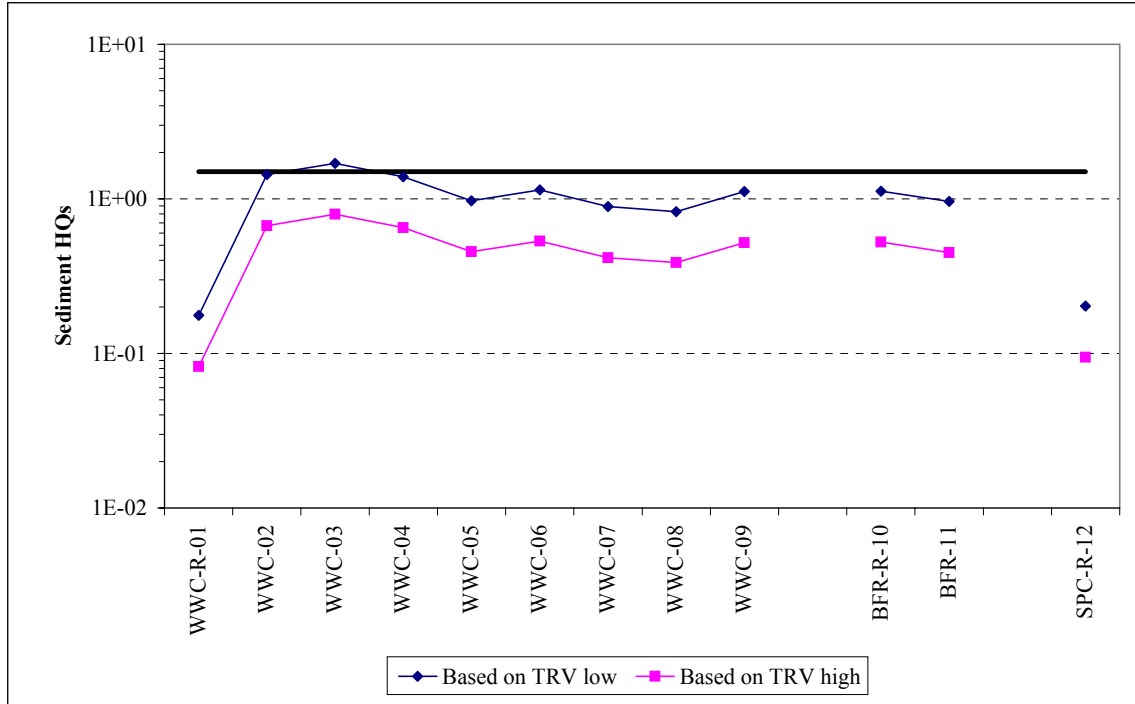
**MERCURY**



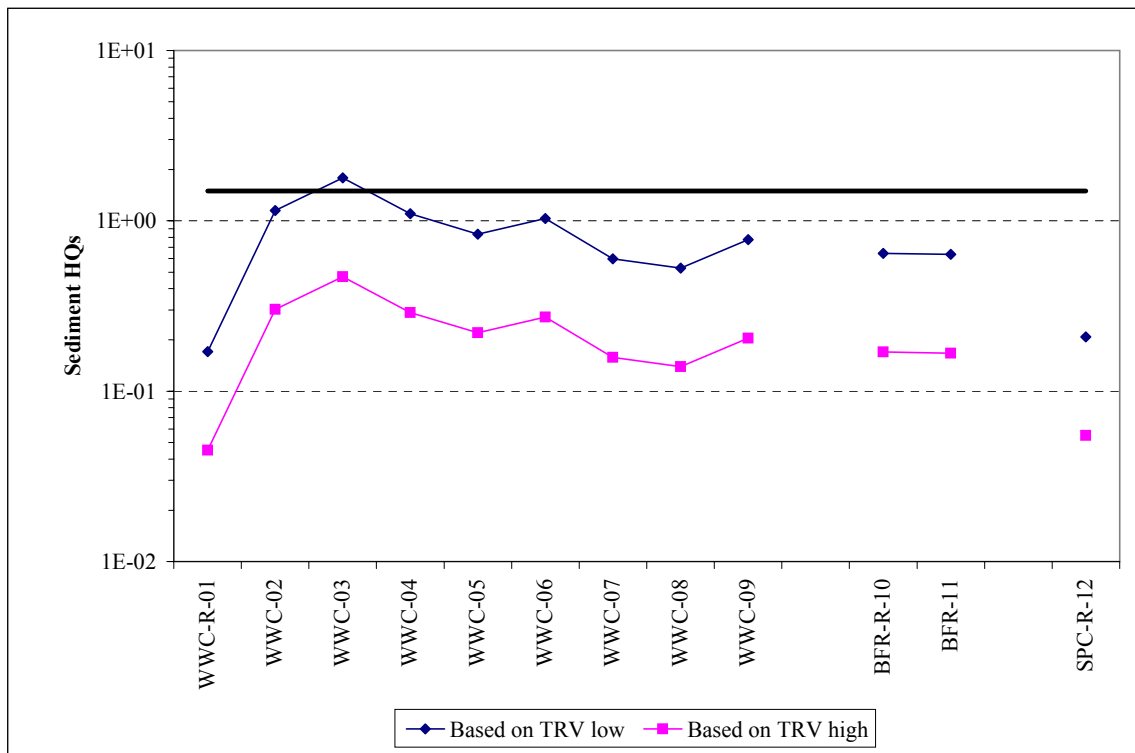
**Figure 6-5**  
**Summary of Sediment HQs for Benthic Macroinvertebrates**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

**NICKEL**



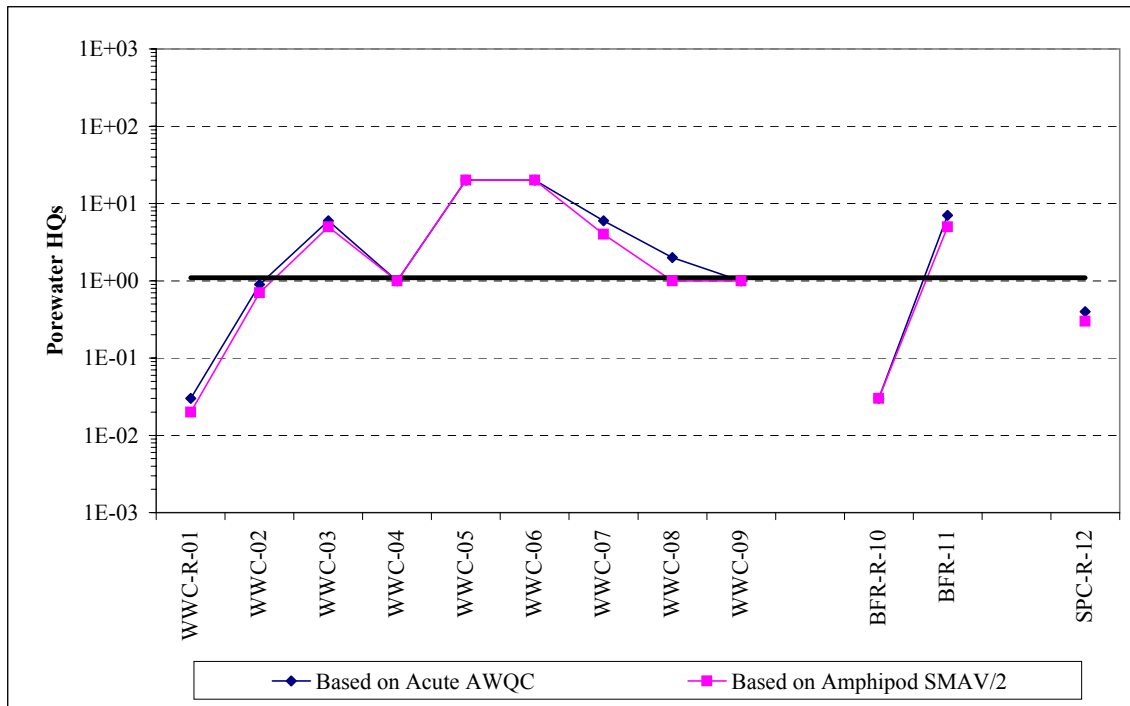
**ZINC**



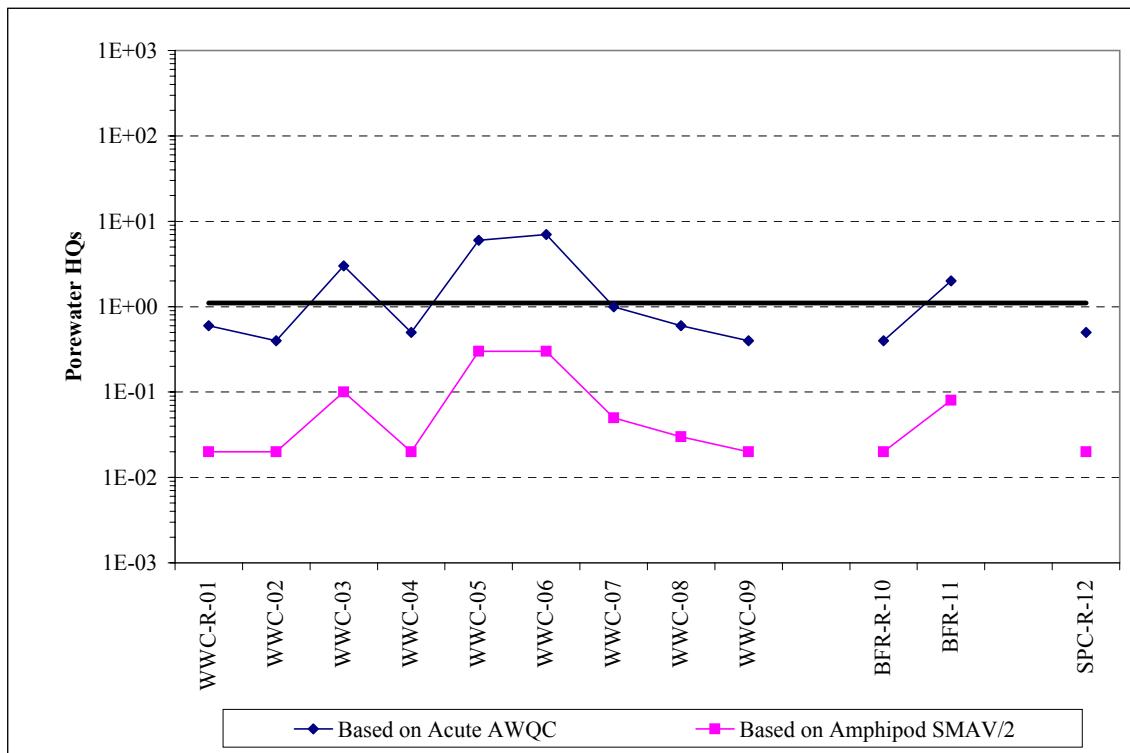
**Figure 6-6**  
**Summary of Pore Water HQs for Benthic Macroinvertebrates**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

**ARSENIC**



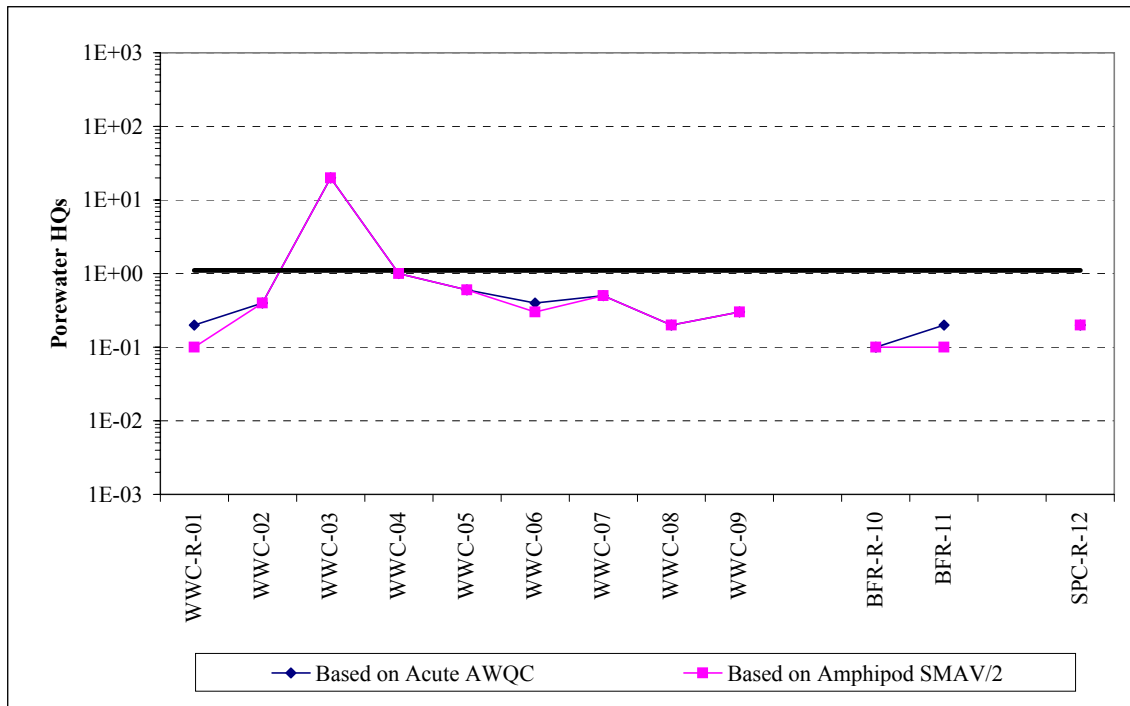
**CADMIUM**



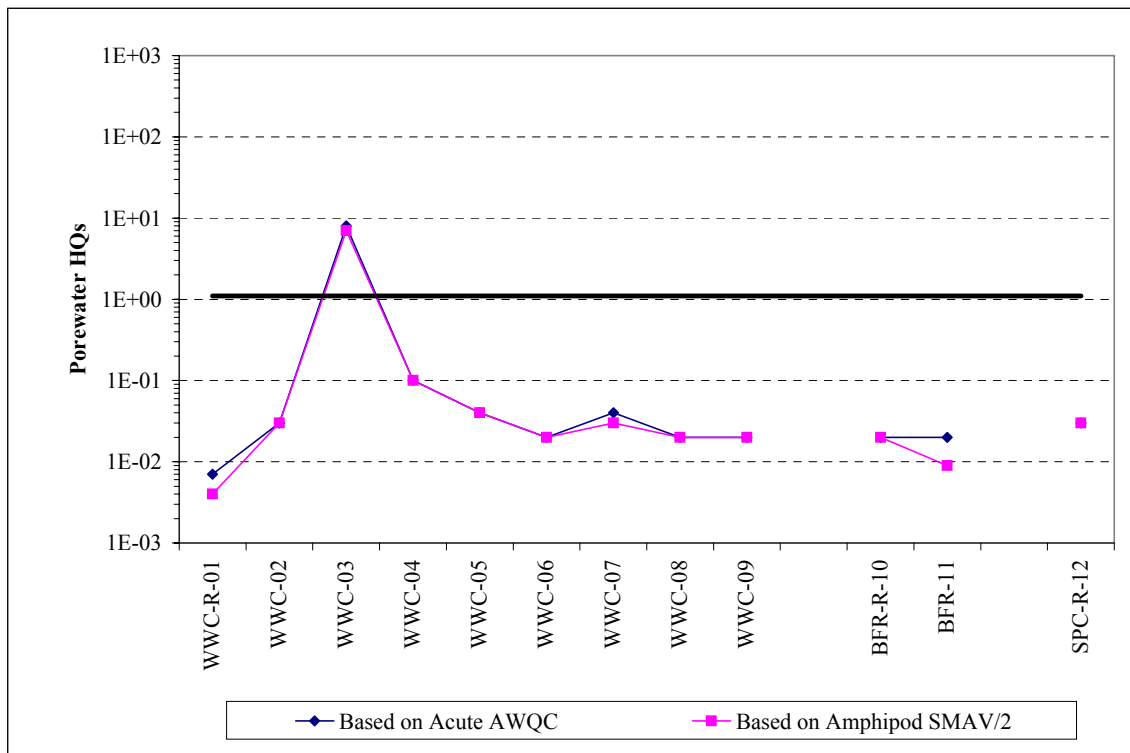
**Figure 6-6**  
**Summary of Pore Water HQs for Benthic Macroinvertebrates**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

**COPPER**



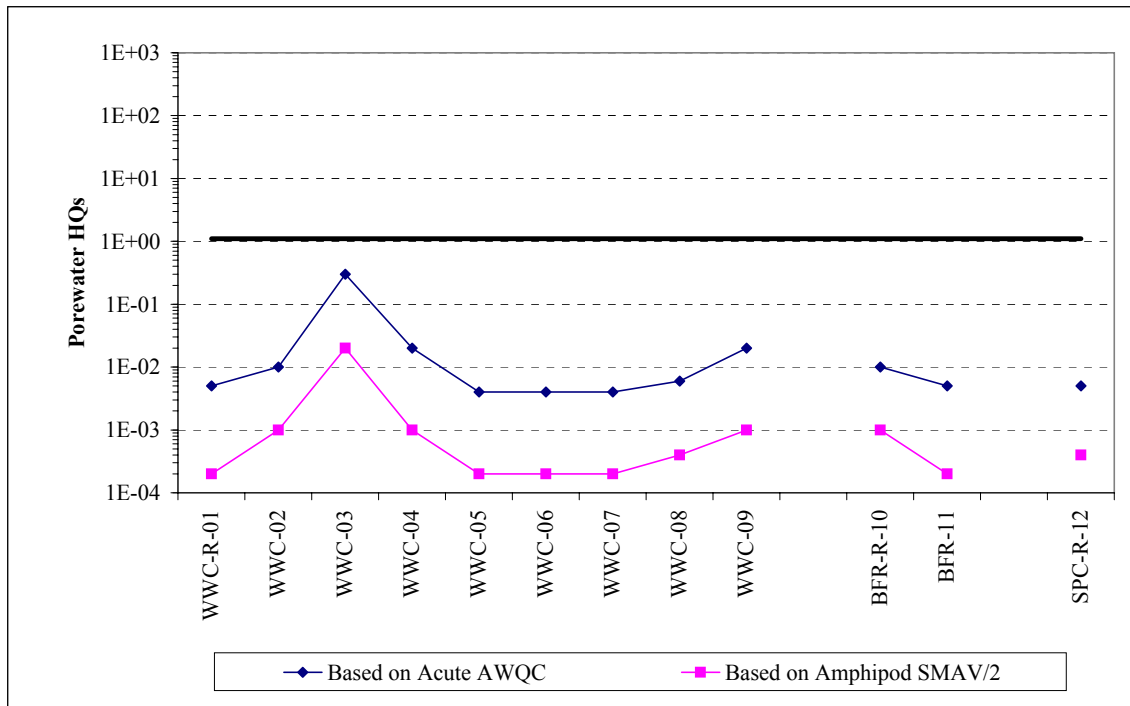
**LEAD**



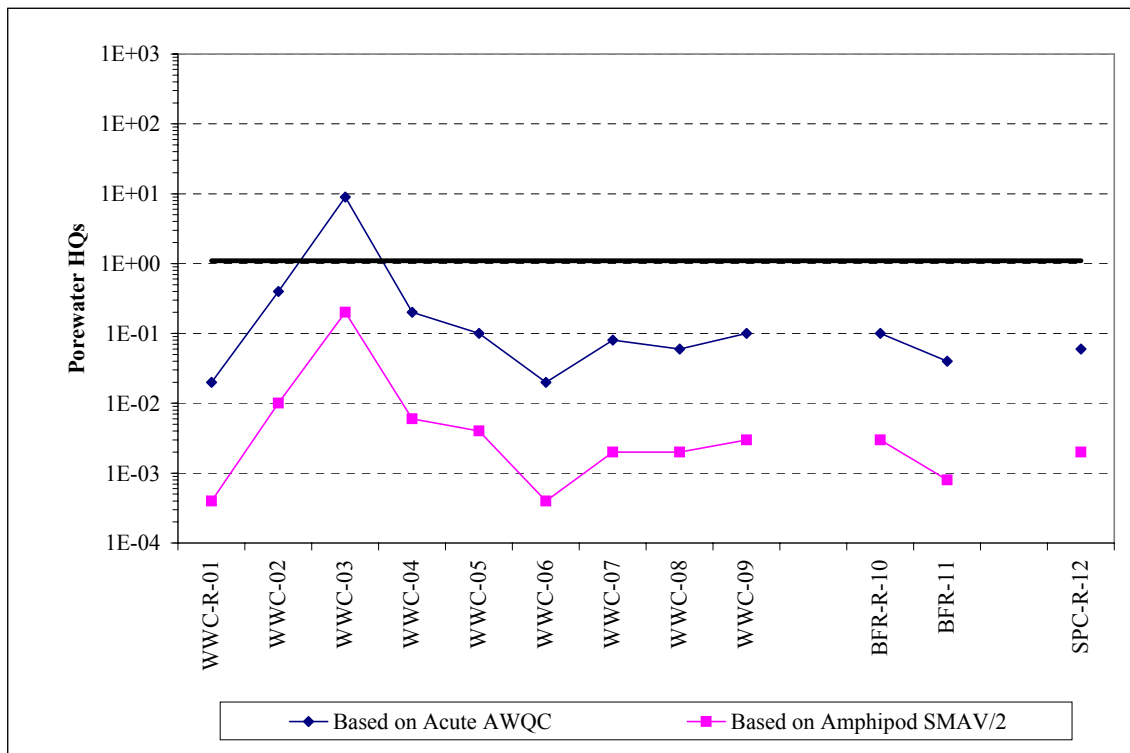
**Figure 6-6**  
**Summary of Pore Water HQs for Benthic Macroinvertebrates**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

**NICKEL**



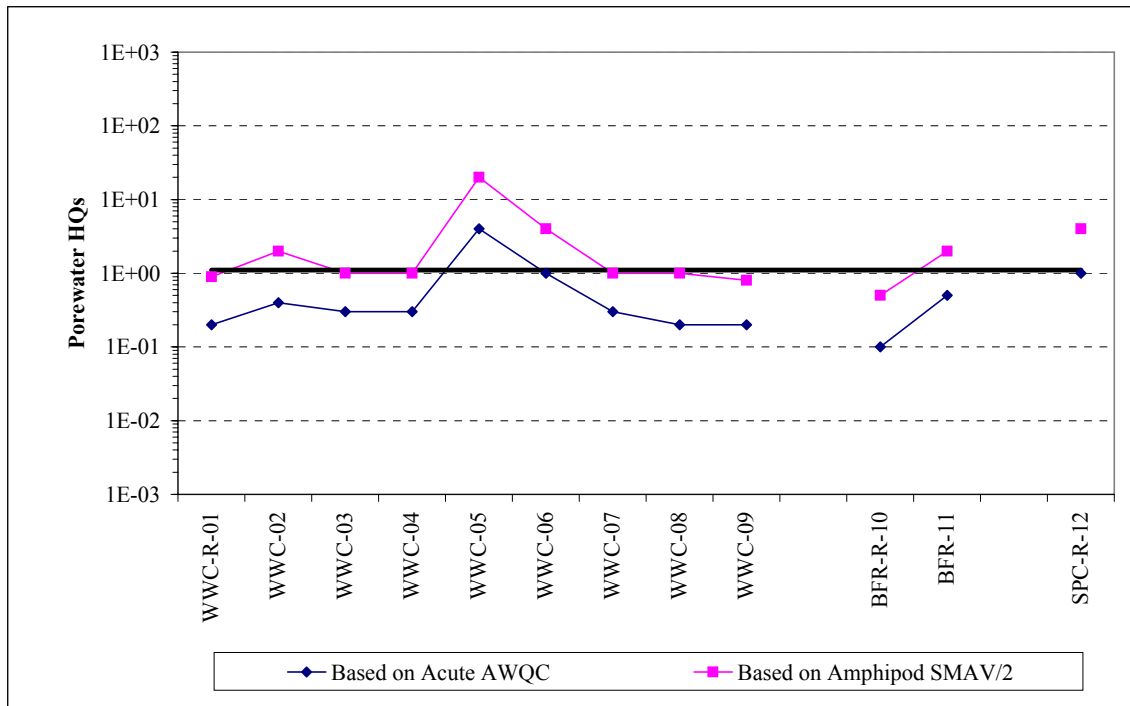
**ZINC**



**Figure 6-6**  
**Summary of Pore Water HQs for Benthic Macroinvertebrates**

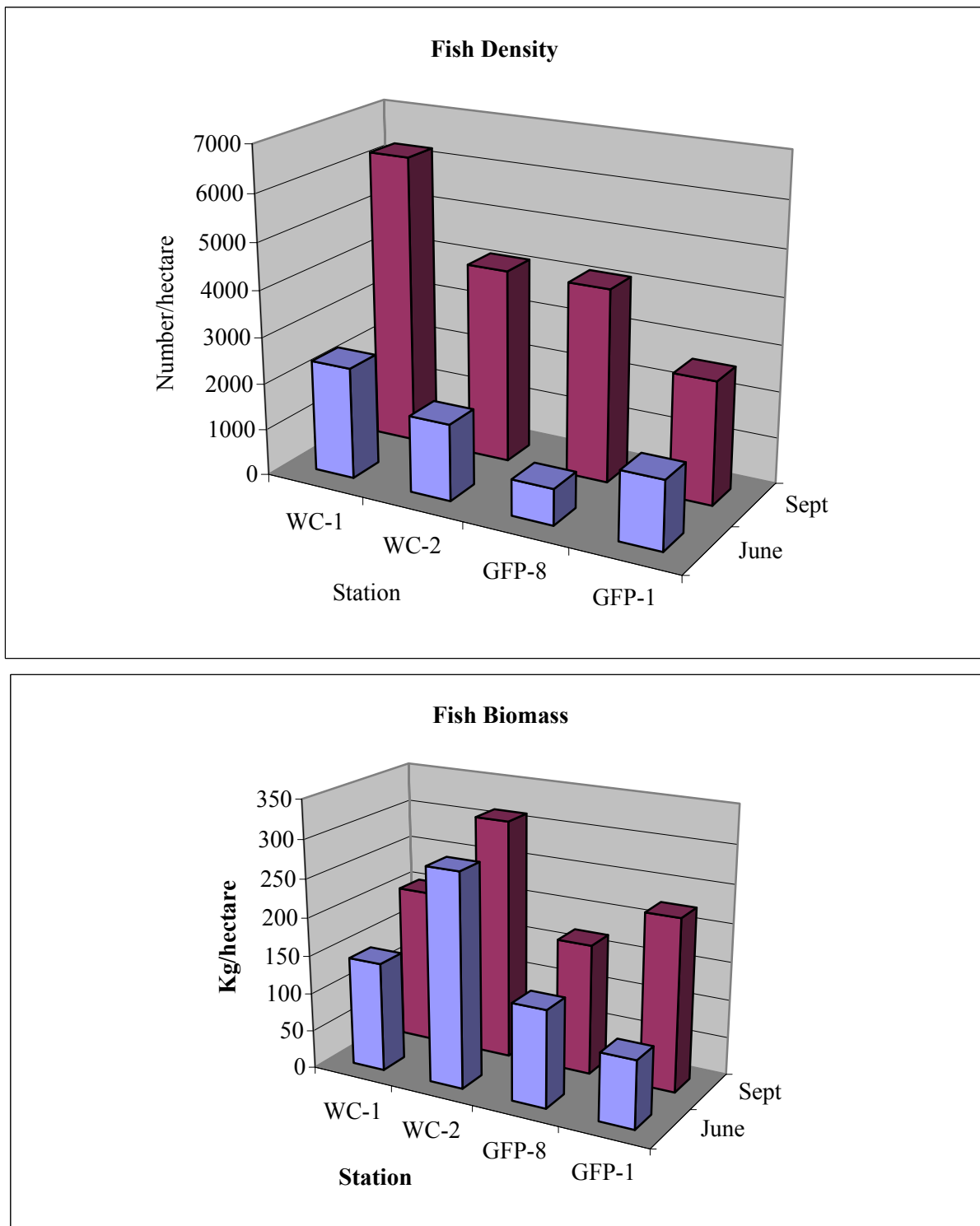
*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

**TOTAL AMMONIA**

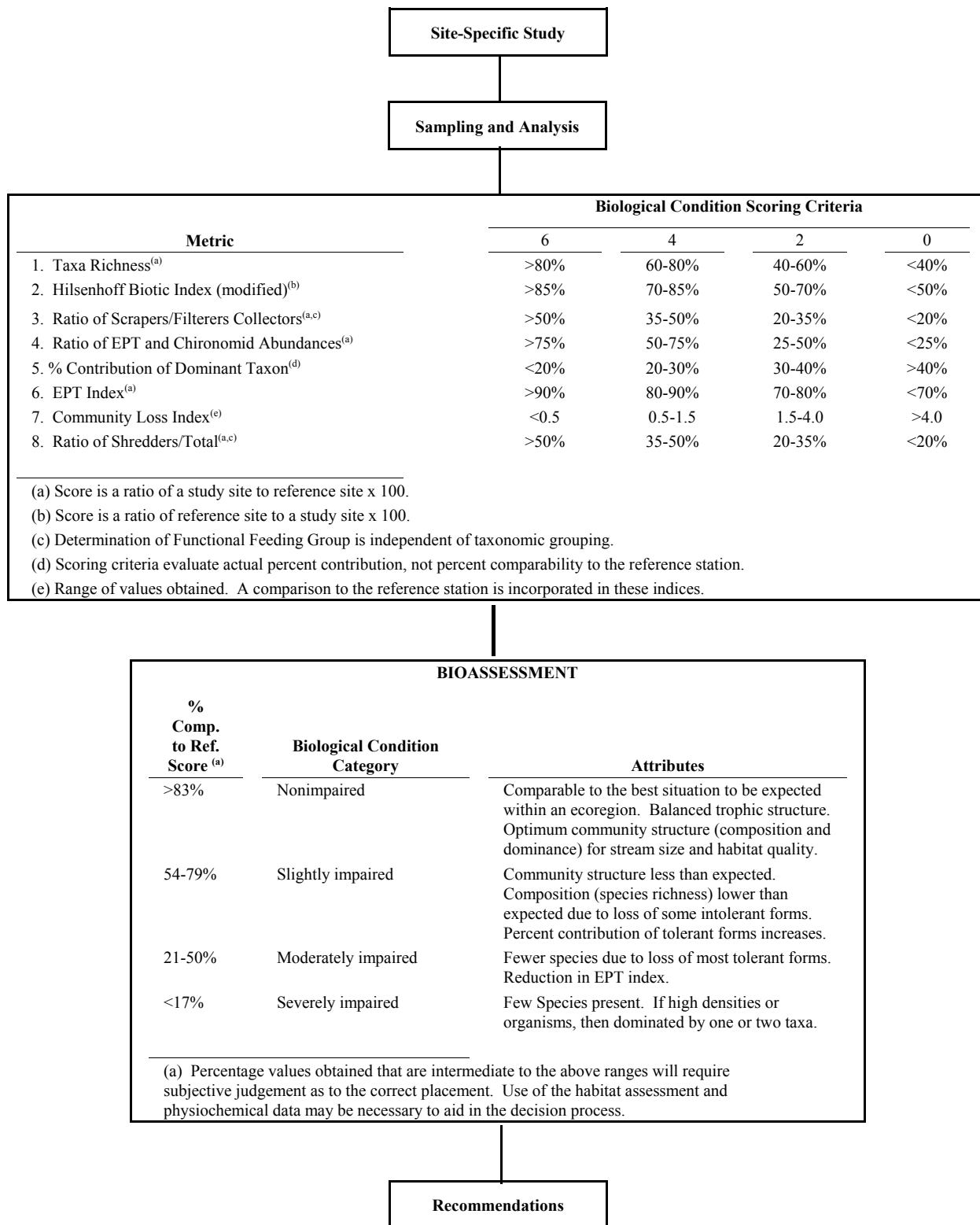


**Figure 6-7 Fish Density and Biomass in Whitewood Creek**

***Ecological Risk Assessment for Whitewood Creek, South Dakota***

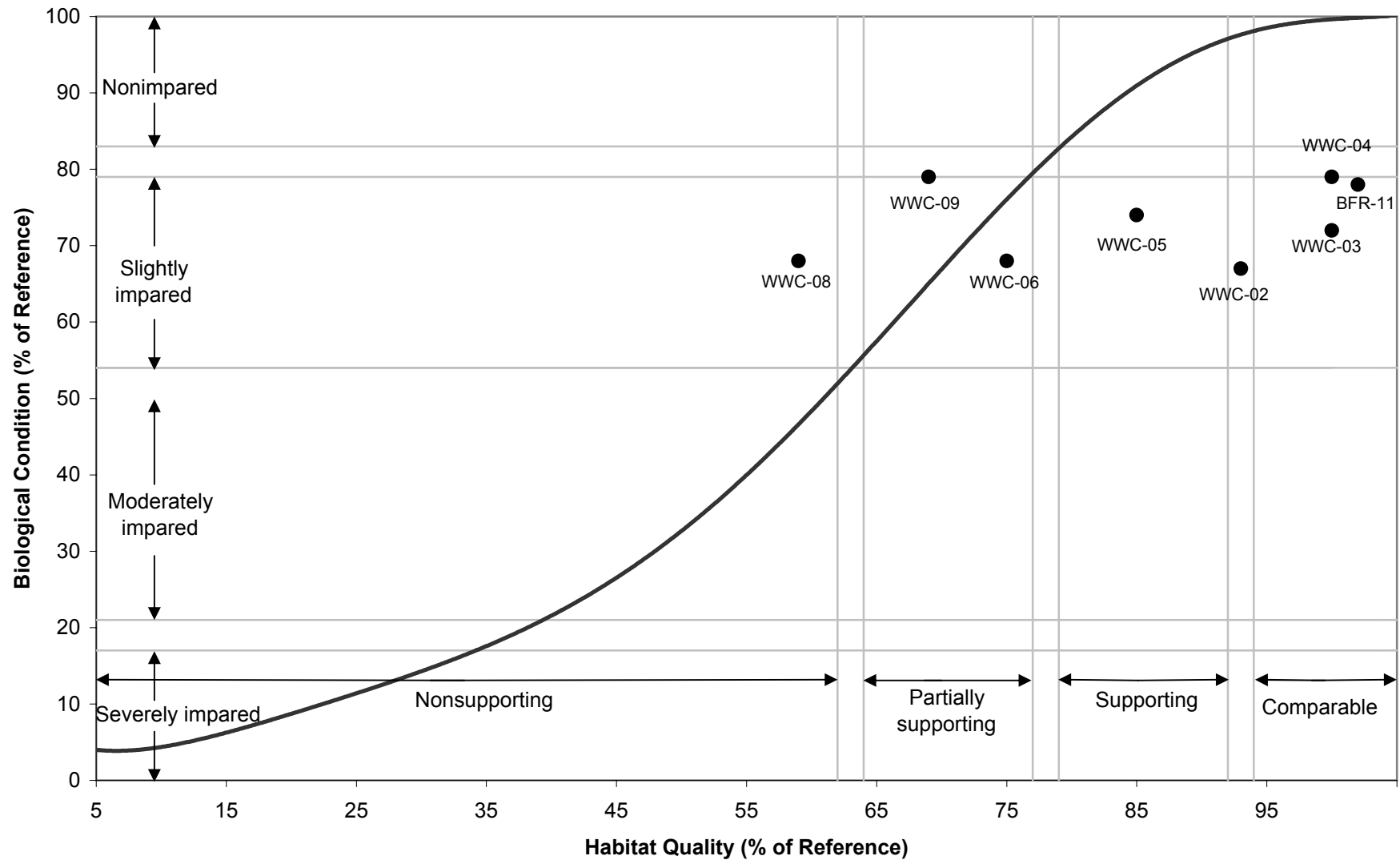


Source: Knudson (2001a, 2001b); only data from 2000 are shown  
WC-1 is identified as the reference area



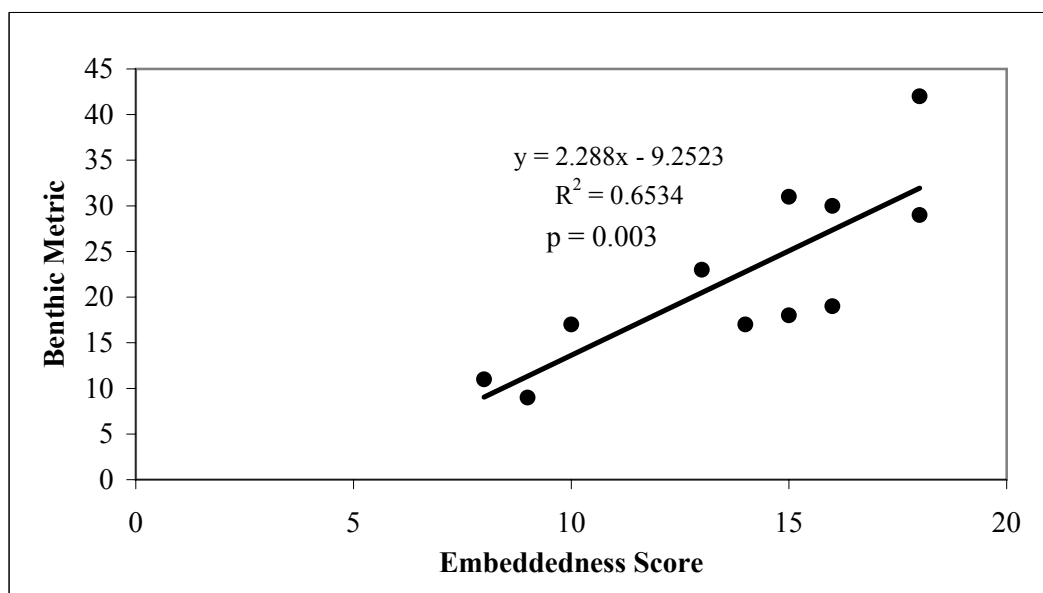
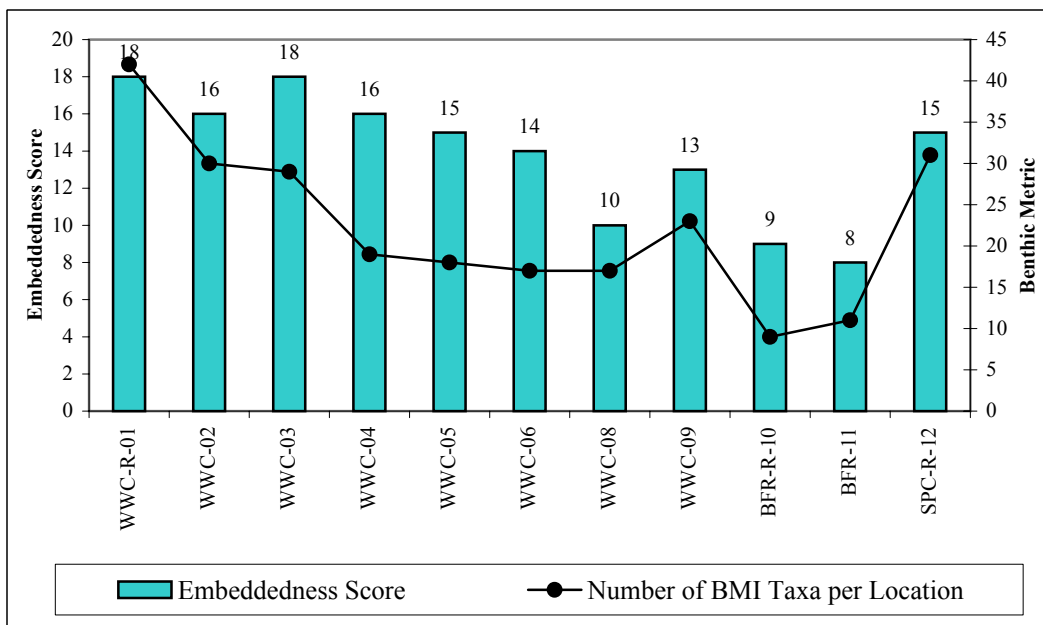
**Figure 6-8**  
**Flowchart of Approach for Rapid Bioassessment Protocol (RBP) III**  
**(U.S. EPA, 1989c)**

**Figure 6-9 Biological Condition of BMI Communities Compared to Expected Values Based on Habitat**



**Figure 6-10**  
**Number of BMI Taxa per Location versus Embeddedness Score**

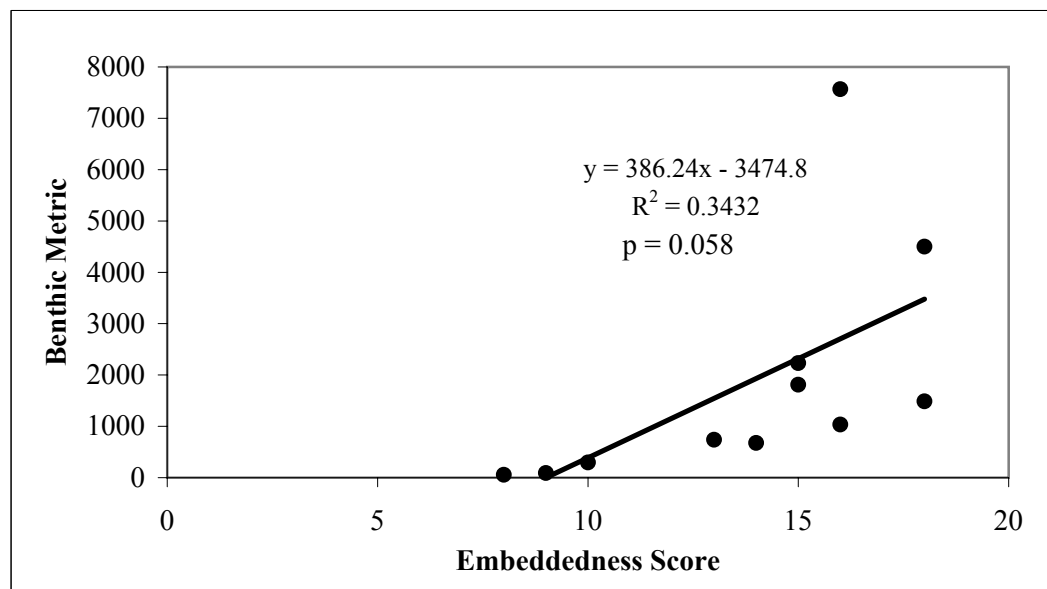
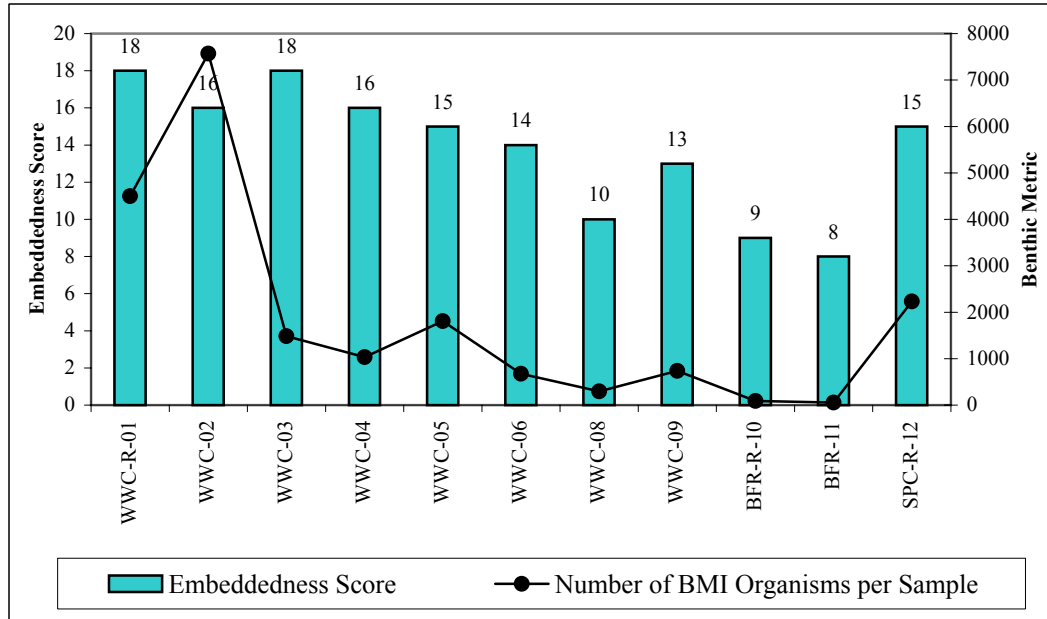
*Ecological Risk Assessment for Whitewood Creek, South Dakota*



Note: Embeddedness score increases with decreasing embeddedness.

**Figure 6-11**  
**Number of BMI Organisms per Sample versus Embeddedness Score**

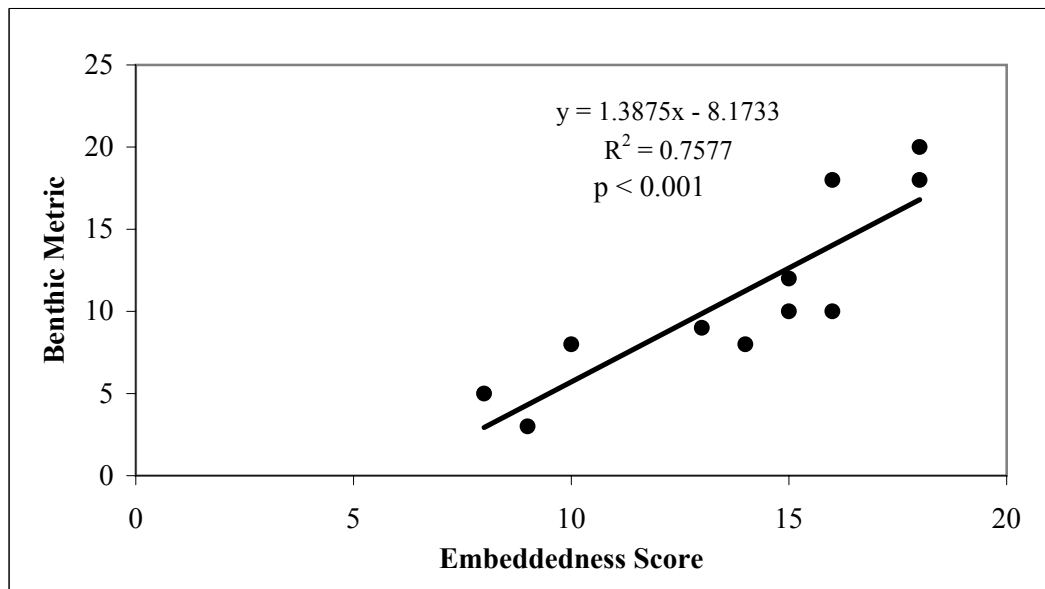
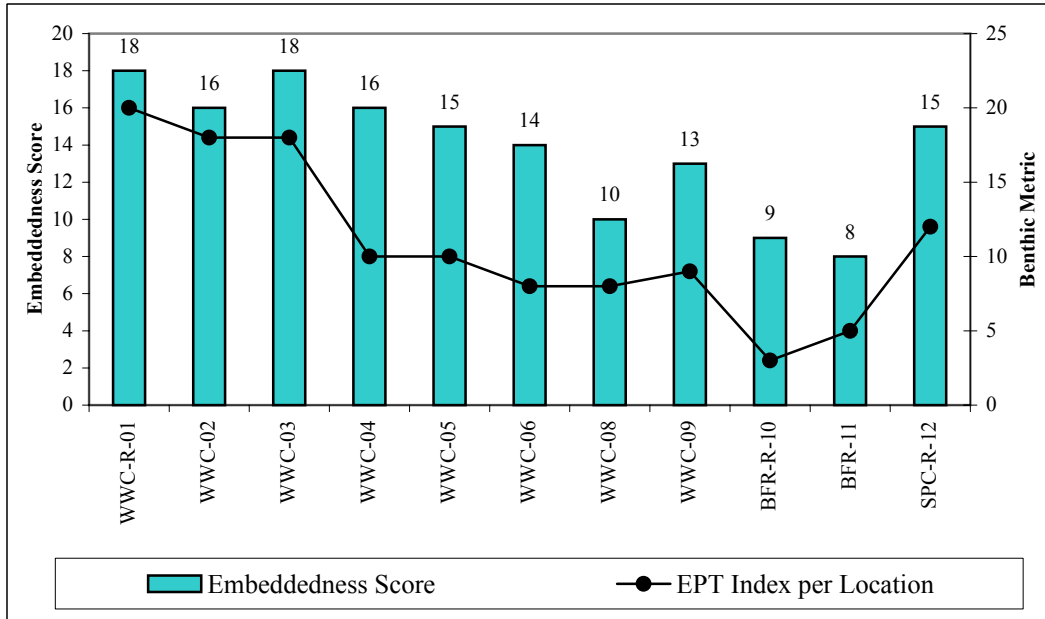
*Ecological Risk Assessment for Whitewood Creek, South Dakota*



Note: Embeddedness score increases with decreasing embeddedness.

**Figure 6-12**  
**EPT Index per Location versus Embeddedness Score**

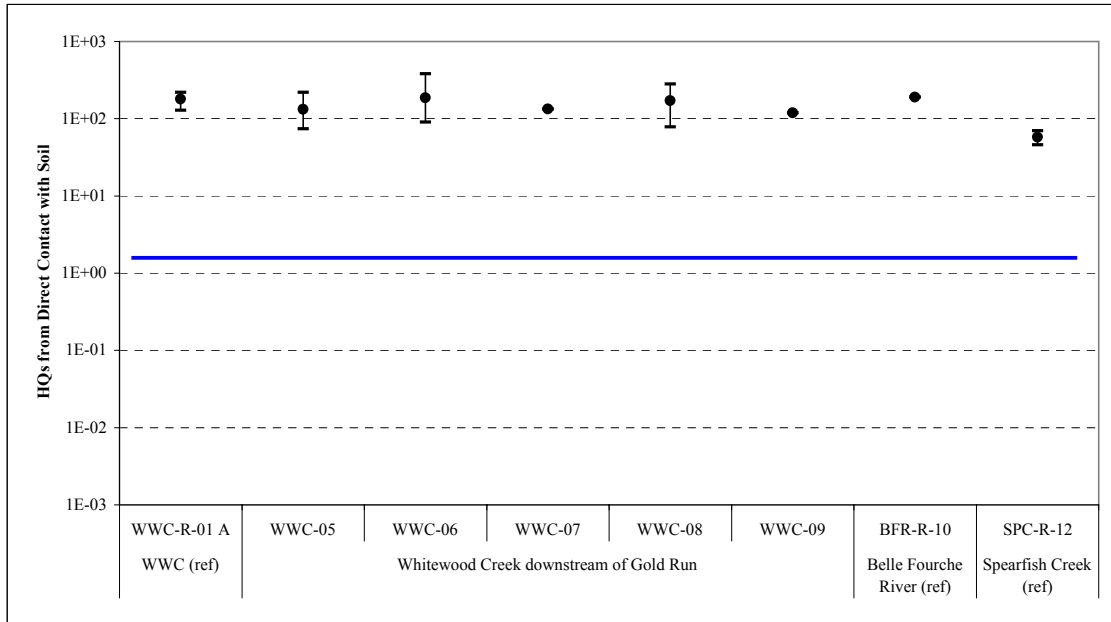
*Ecological Risk Assessment for Whitewood Creek, South Dakota*



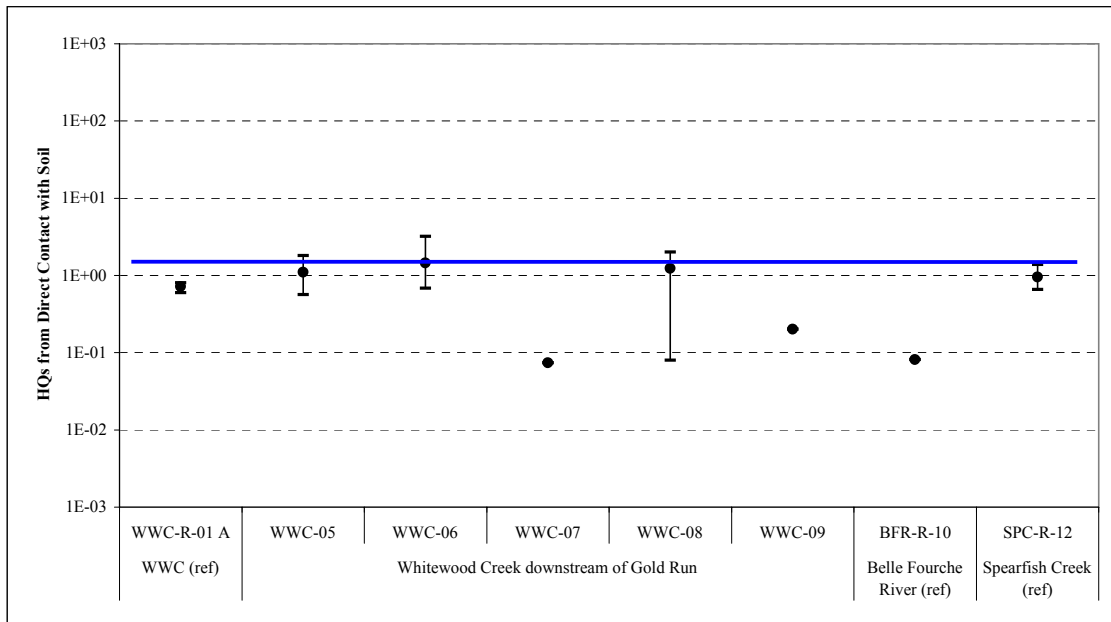
Note: Embeddedness score increases with decreasing embeddedness.

**Figure 7-1**  
**Calculation of HQs for the Direct Contact of Plants with Soil**

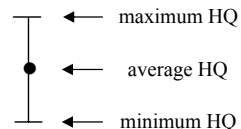
**ALUMINUM**



**ANTIMONY**

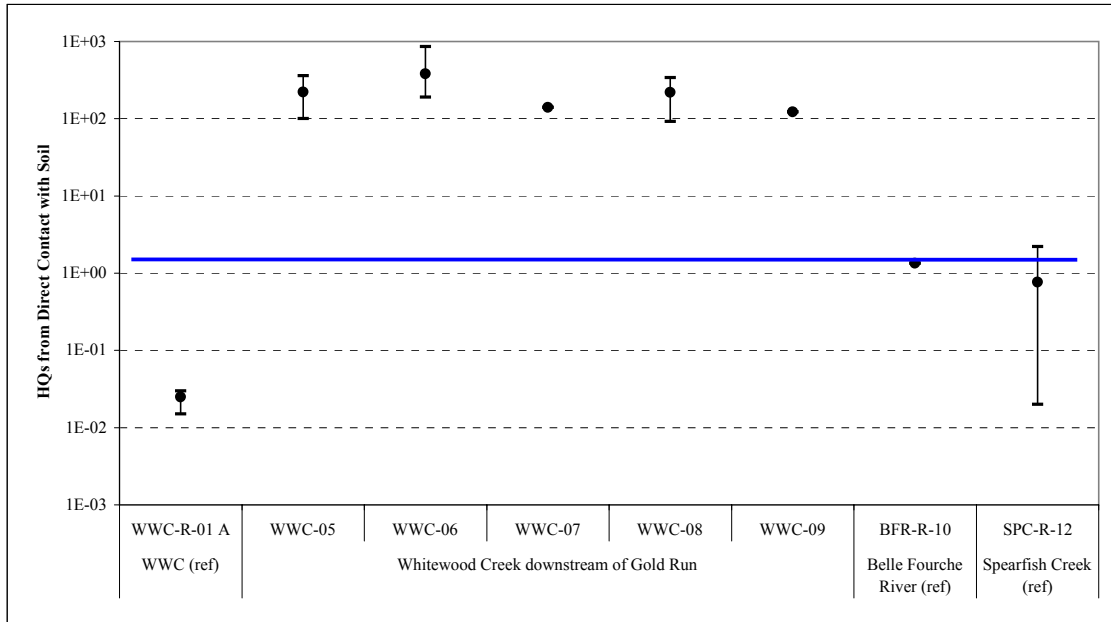


**LEGEND:**

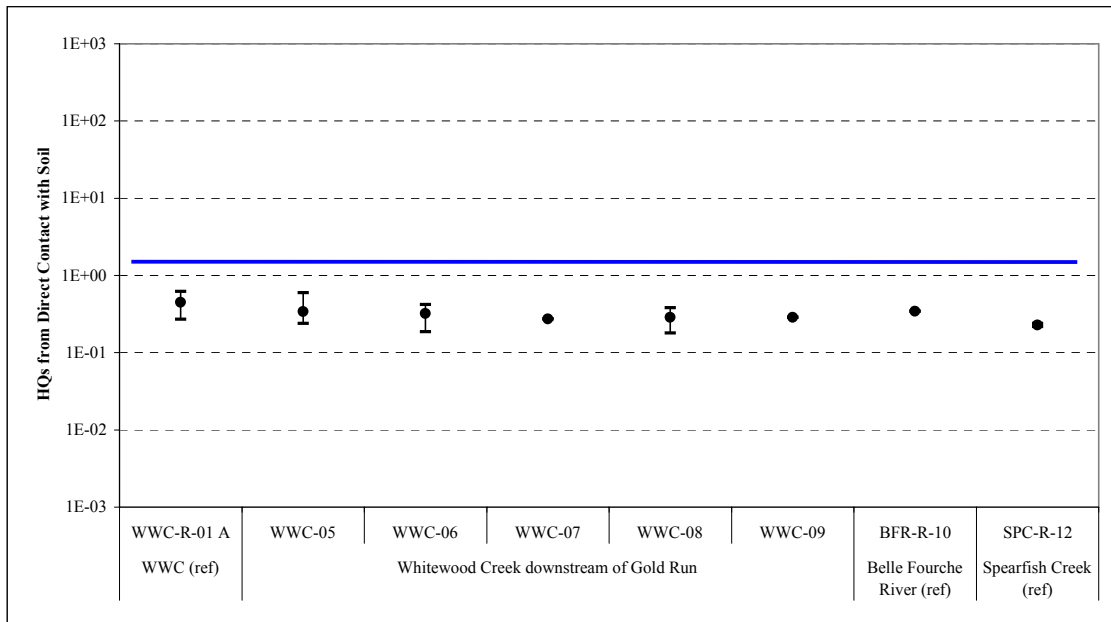


**Figure 7-1 (cont.)**  
**Calculation of HQs for the Direct Contact of Plants with Soil**

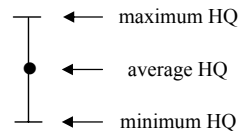
**ARSENIC**



**BARIUM**

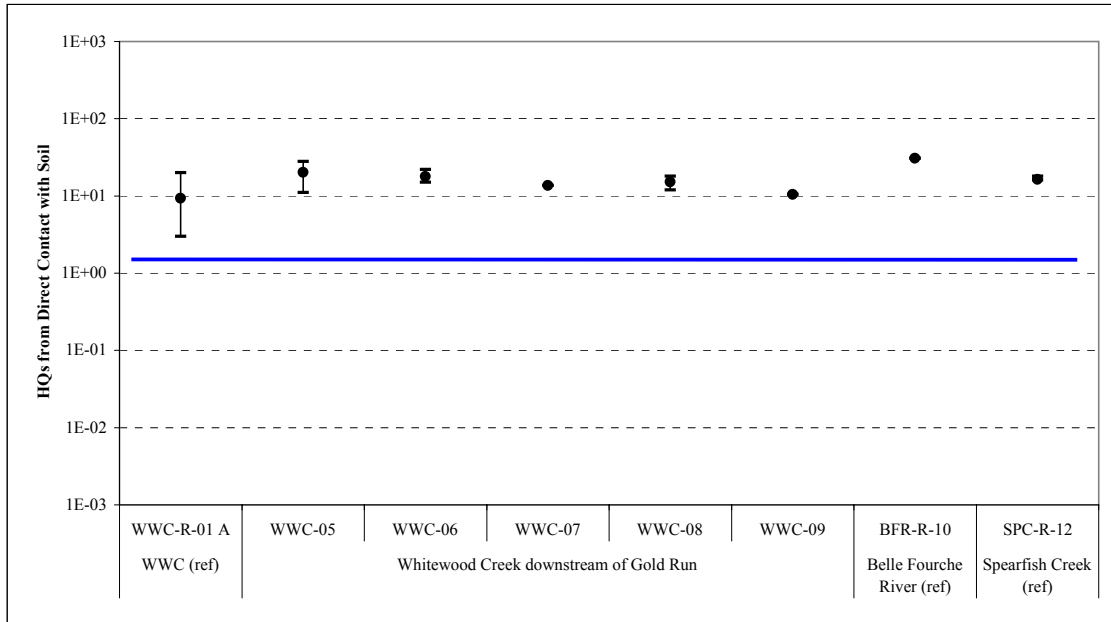


**LEGEND:**

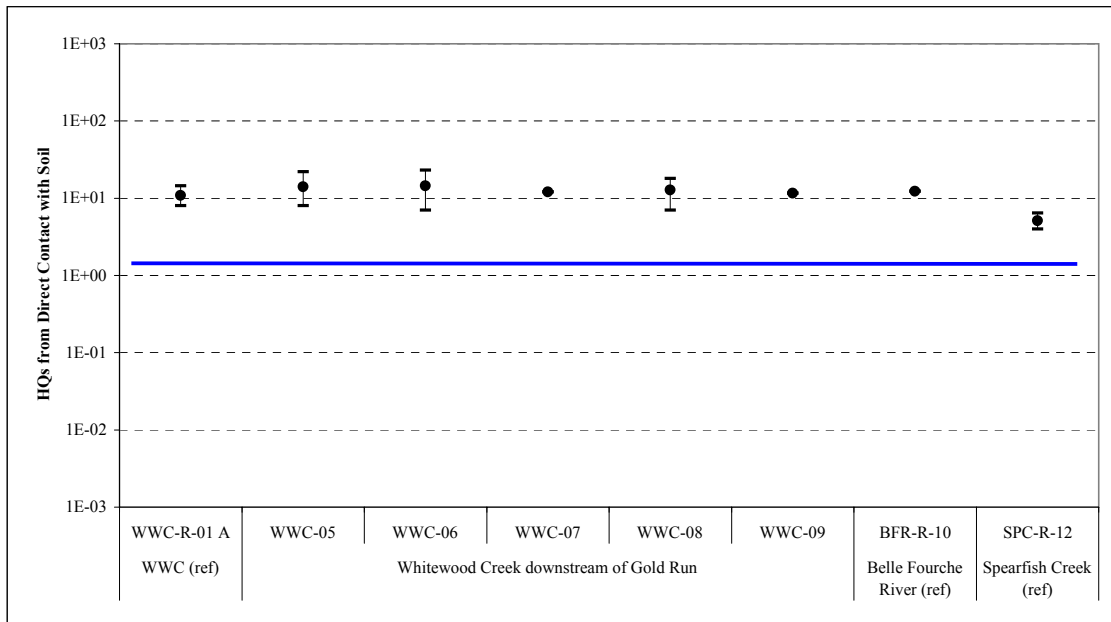


**Figure 7-1 (cont.)**  
**Calculation of HQs for the Direct Contact of Plants with Soil**

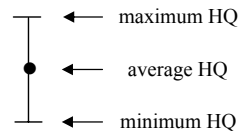
**BORON**



**CHROMIUM**

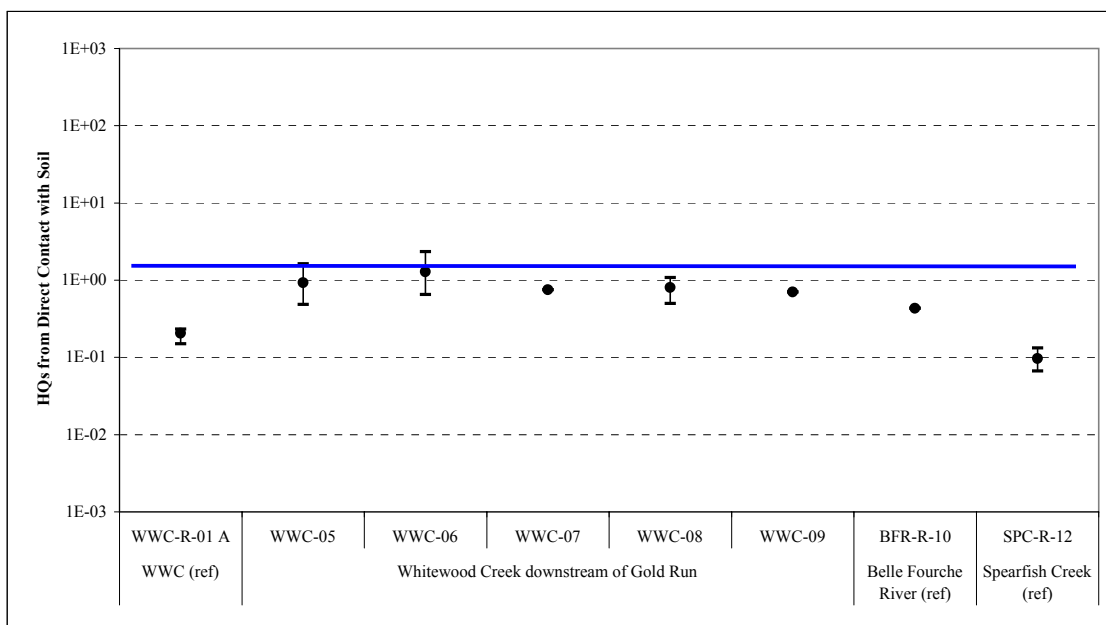


**LEGEND:**

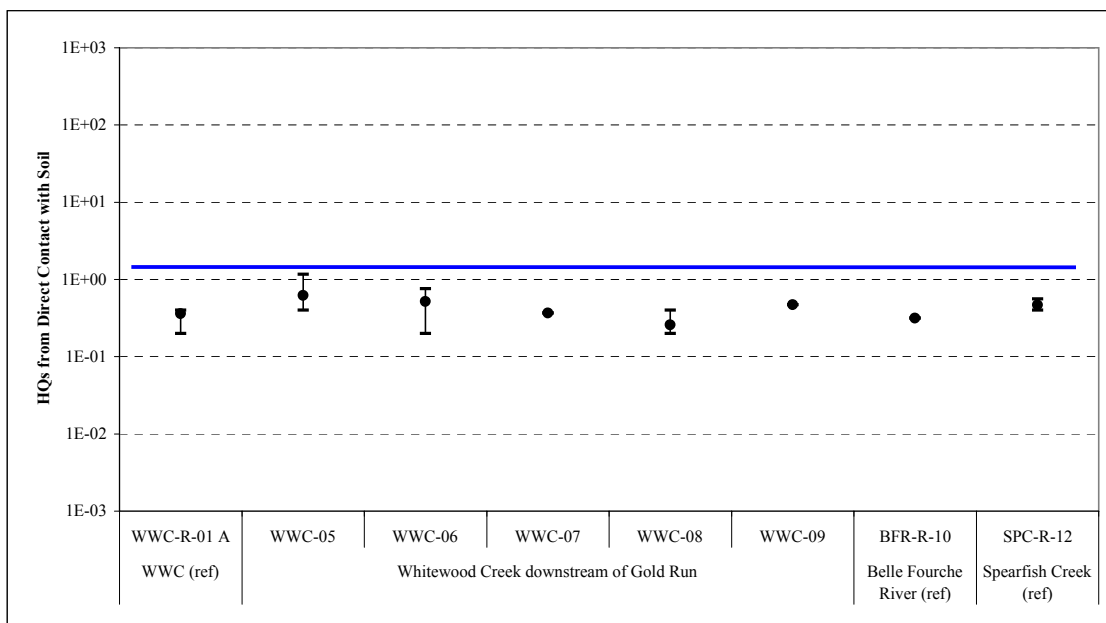


**Figure 7-1 (cont.)**  
**Calculation of HQs for Direct Contact of Plants with Soil**

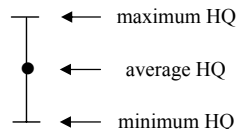
**COPPER**



**LEAD**

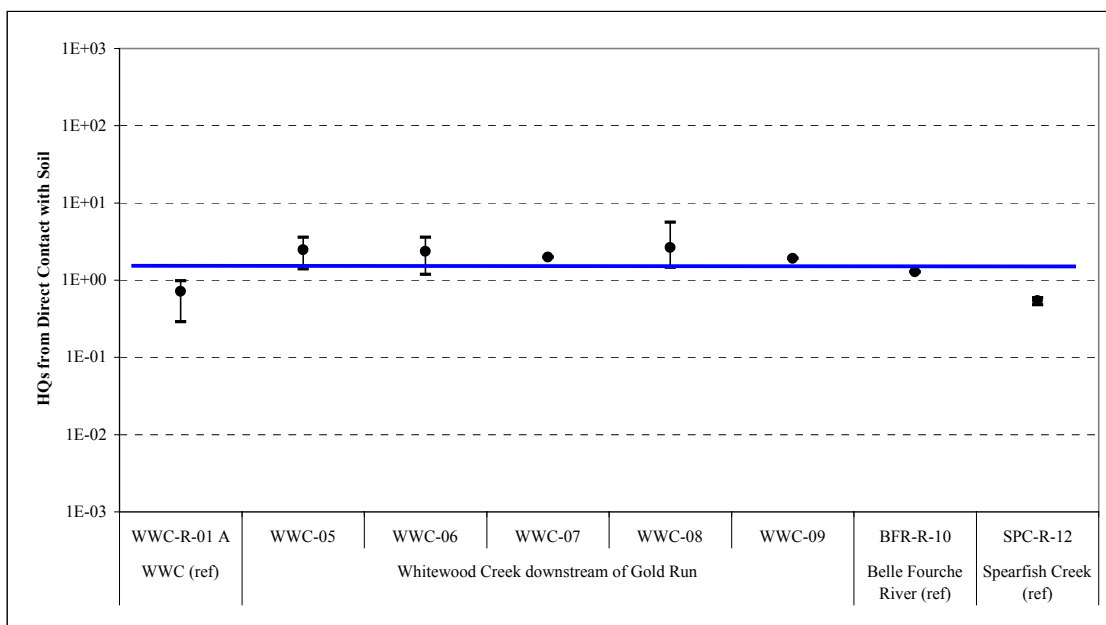


**LEGEND:**

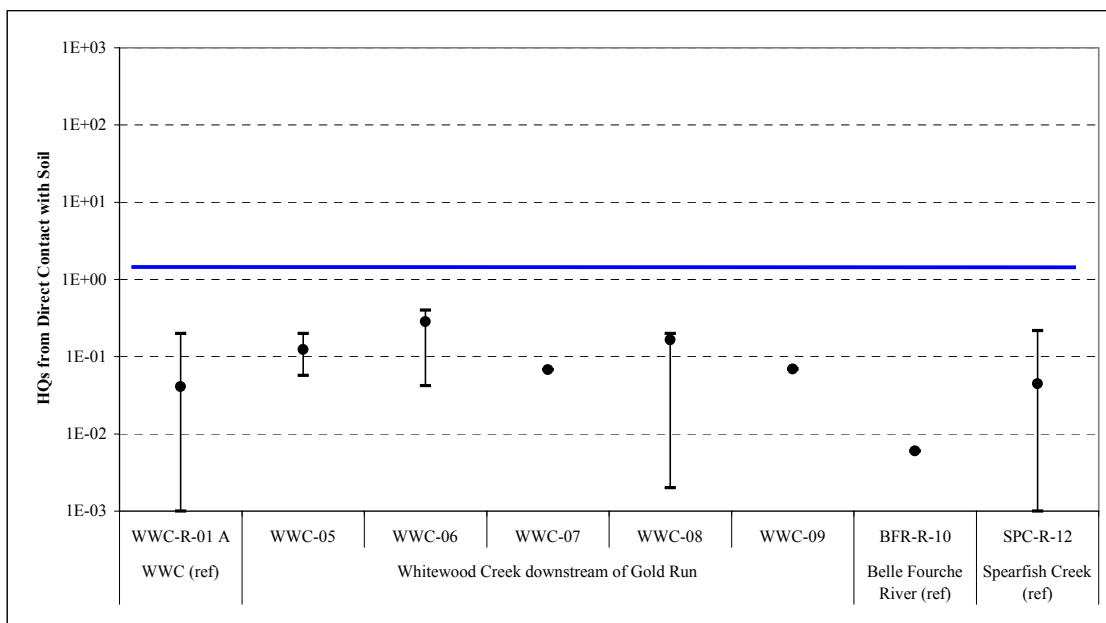


**Figure 7-1 (cont.)**  
**Calculation of HQs for Direct Contact of Plants with Soil**

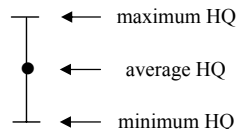
**MANGANESE**



**MERCURY**

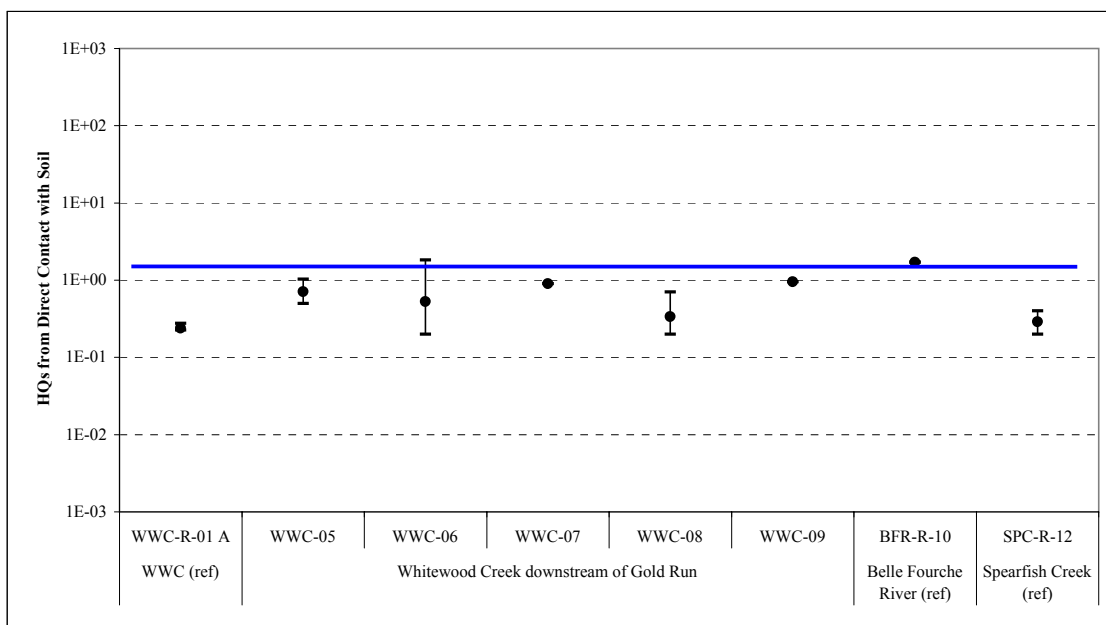


**LEGEND:**

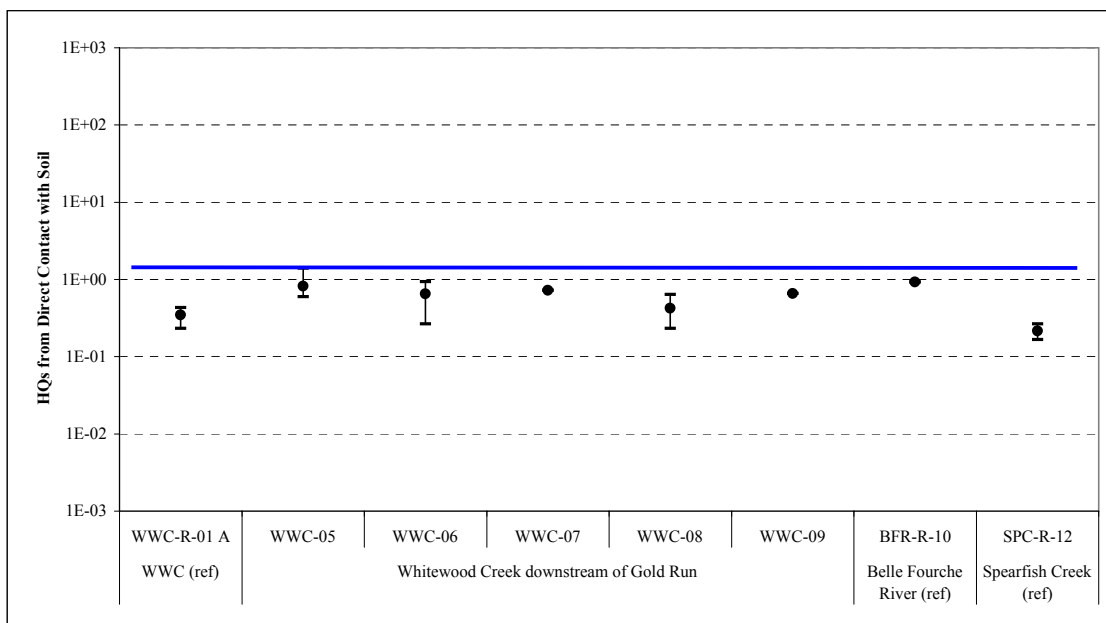


**Figure 7-1 (cont.)**  
**Calculation of HQs for Direct Contact of Plants with Soil**

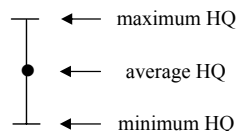
**MOLYBDENUM**



**NICKEL**

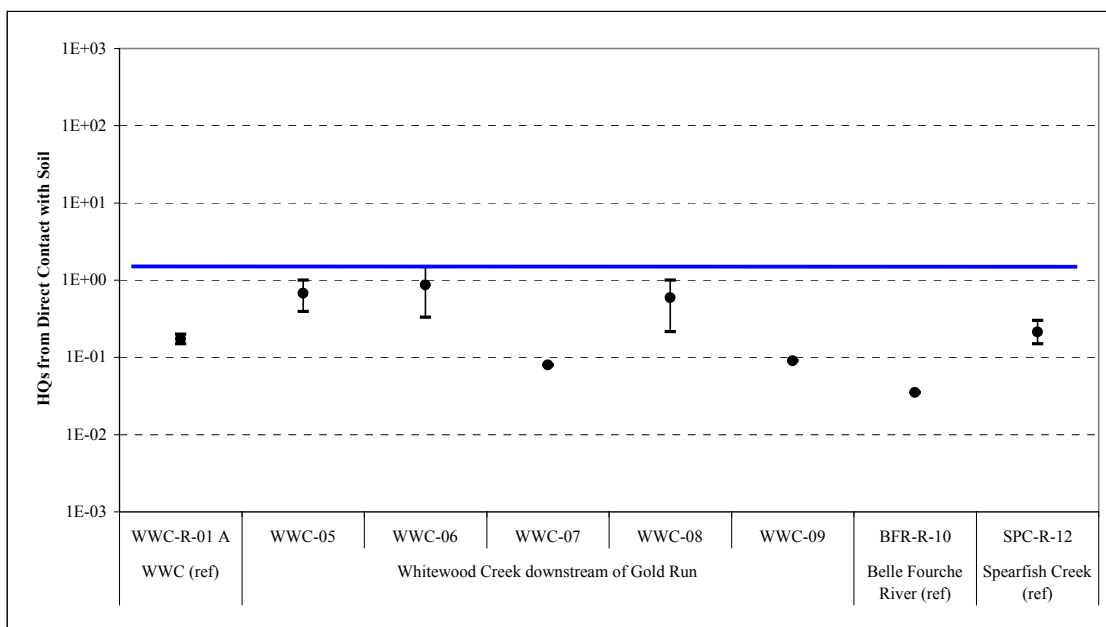


**LEGEND:**

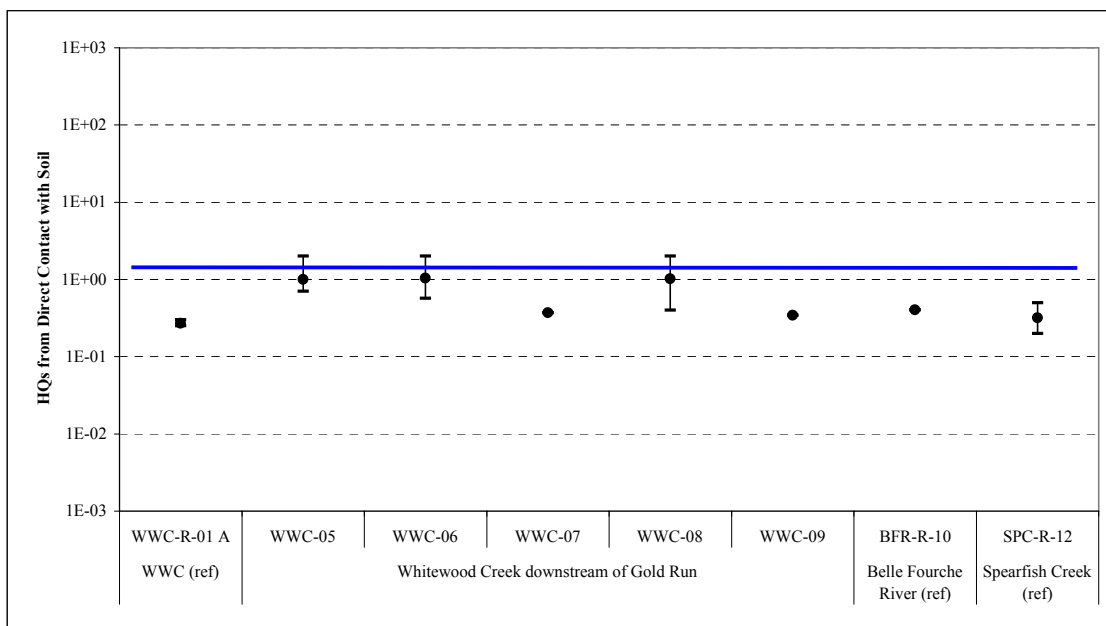


**Figure 7-1 (cont.)**  
**Calculation of HQs for Direct Contact of Plants with Soil**

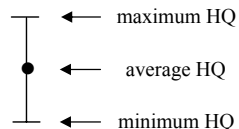
**SILVER**



**THALLIUM**

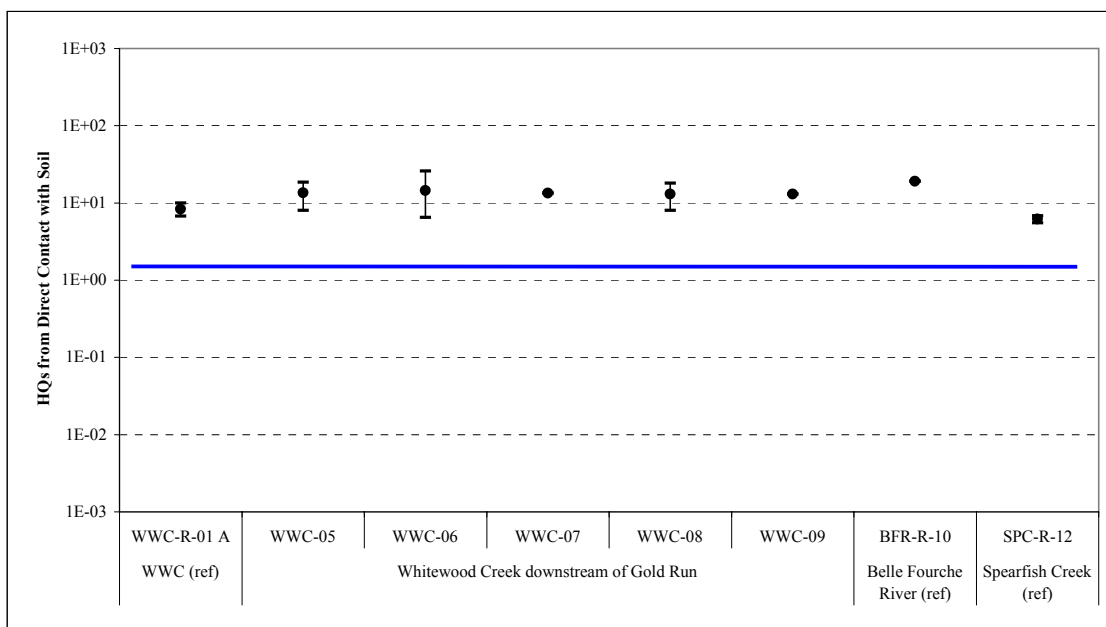


**LEGEND:**

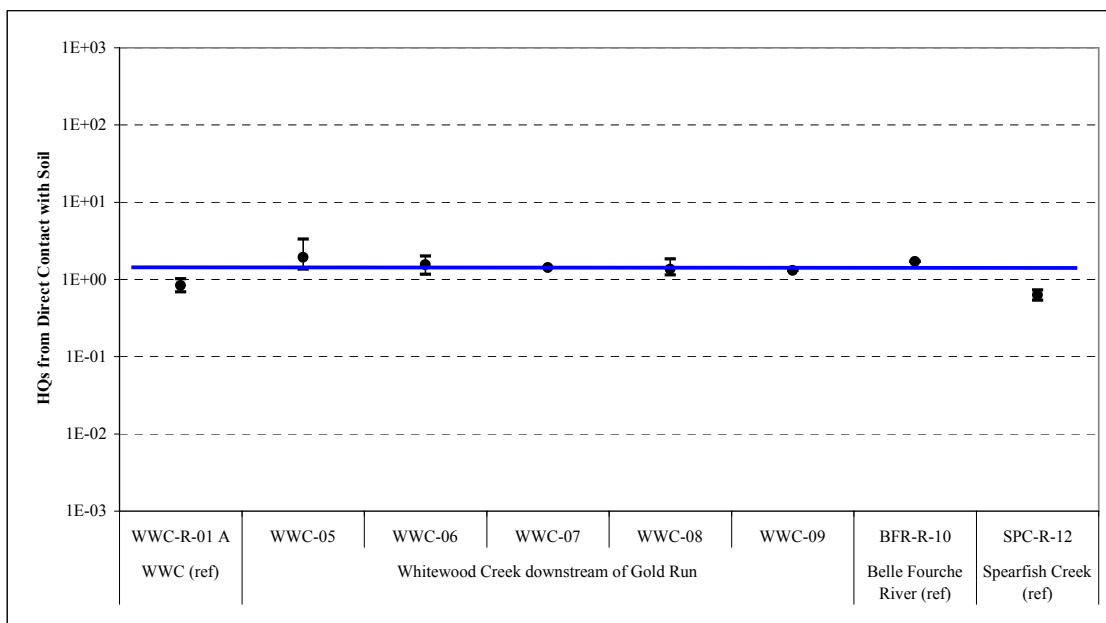


**Figure 7-1 (cont.)**  
**Calculation of HQs for Direct Contact of Plants with Soil**

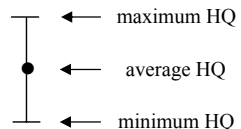
**VANADIUM**



**ZINC**

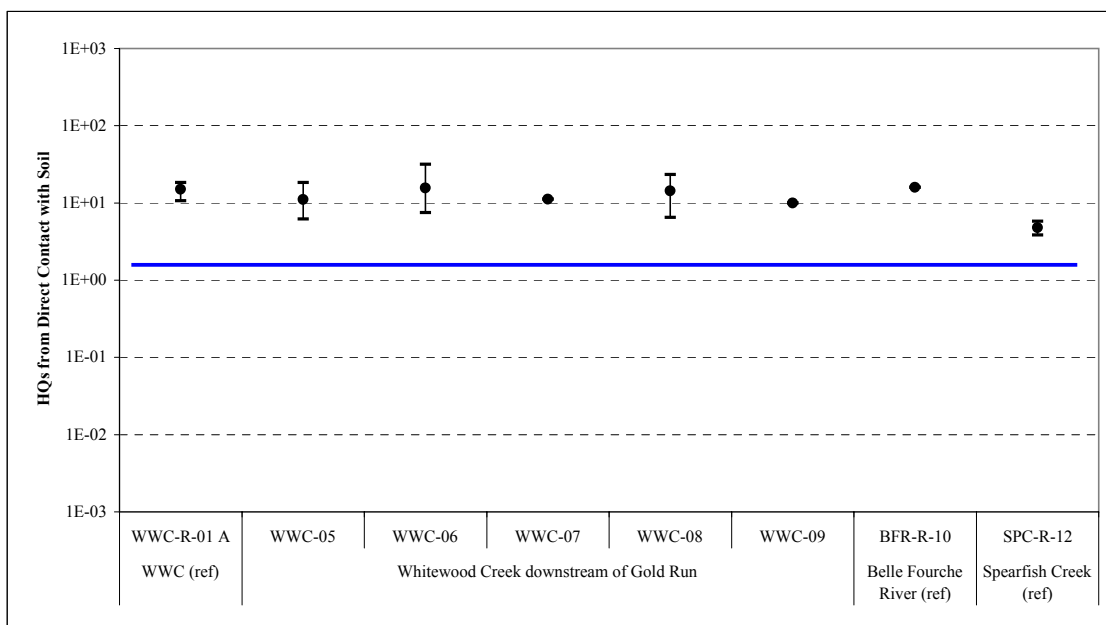


**LEGEND:**

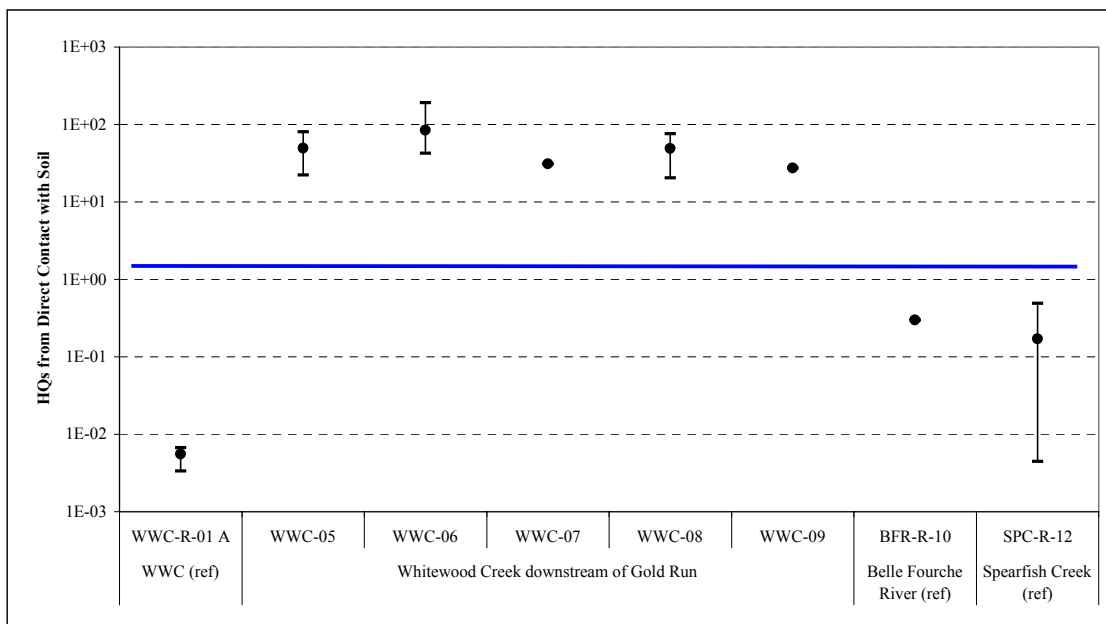


**Figure 7-2**  
**Calculation of HQs for Direct Contact of Soil Invertebrates with Soil**

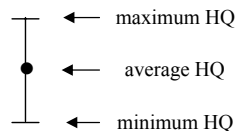
**ALUMINUM**



**ARSENIC**

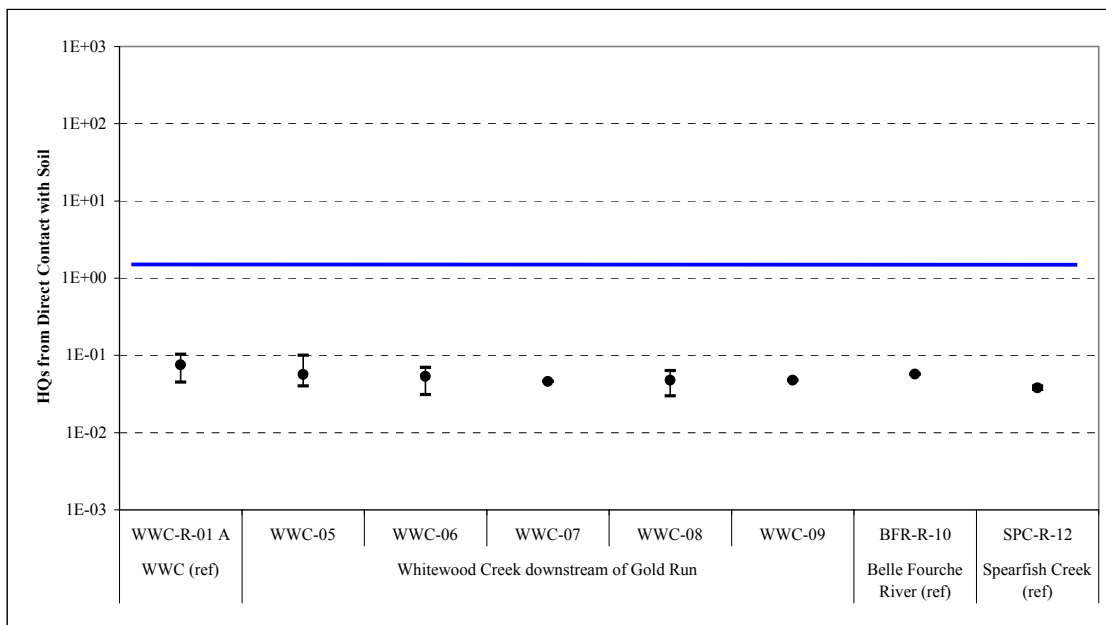


**LEGEND:**

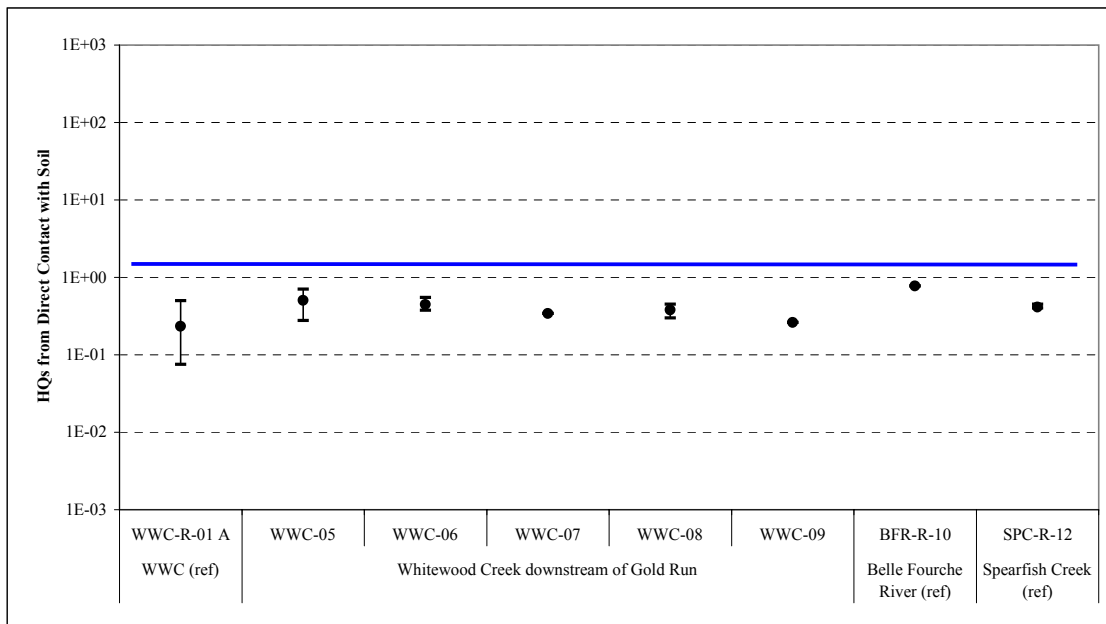


**Figure 7-2 (cont.)**  
**Calculation of HQs for Direct Contact of Soil Invertebrates with Soil**

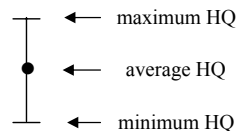
**BARIUM**



**BORON**

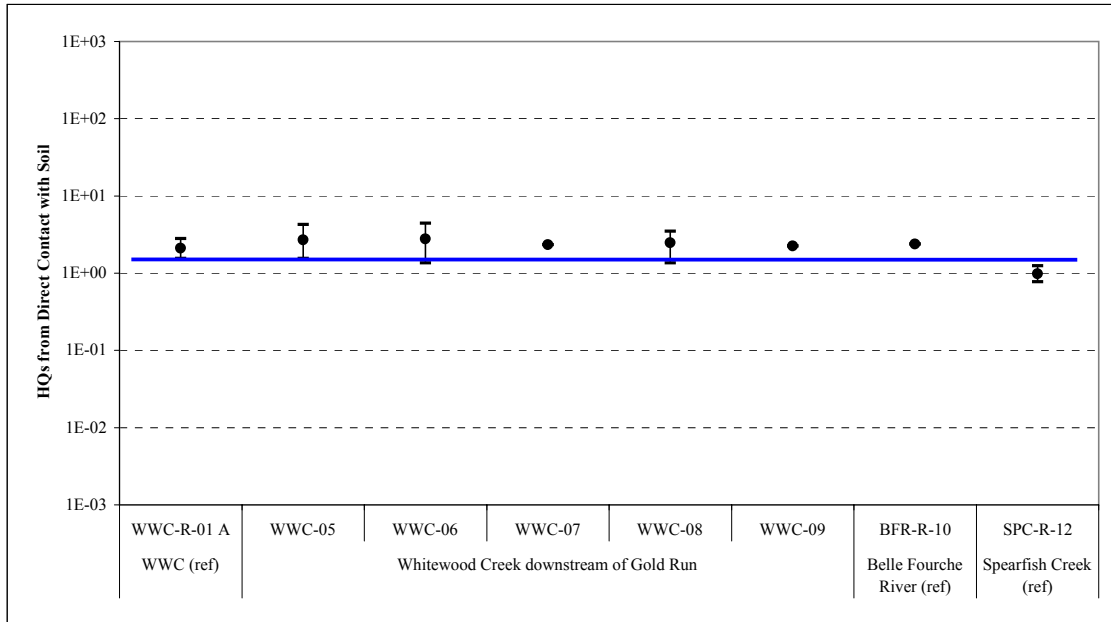


**LEGEND:**

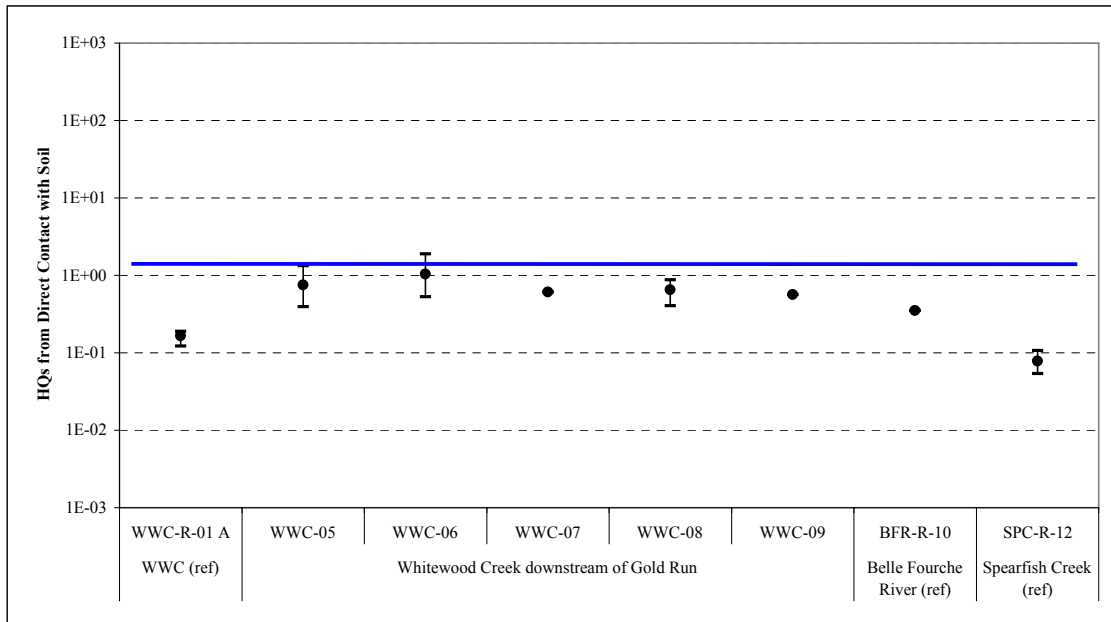


**Figure 7-2 (cont.)**  
**Calculation of HQs for Direct Contact of Soil Invertebrates with Soil**

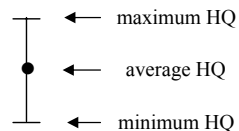
**CHROMIUM**



**COPPER**

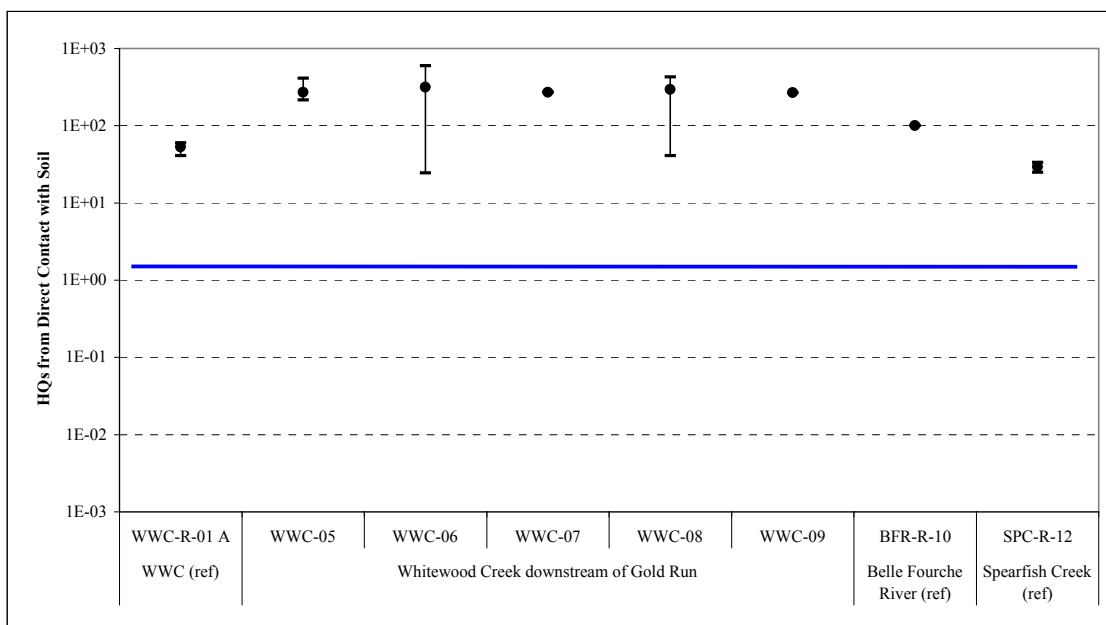


**LEGEND:**

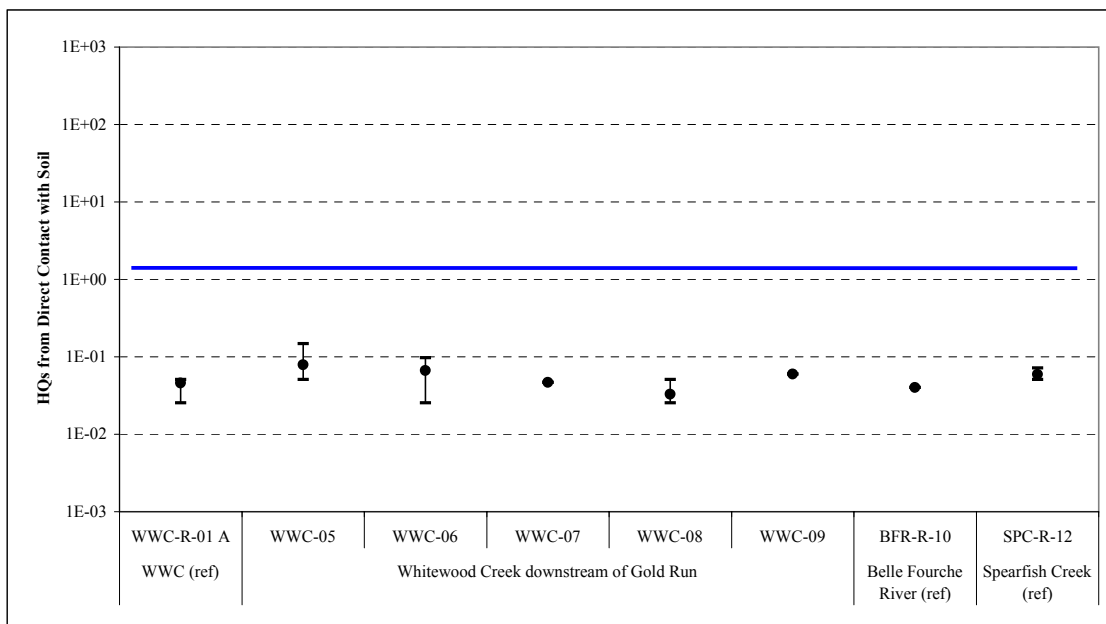


**Figure 7-2 (cont.)**  
**Calculation of HQs for Direct Contact of Soil Invertebrates with Soil**

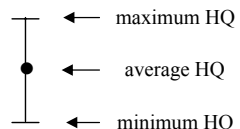
**IRON**



**LEAD**

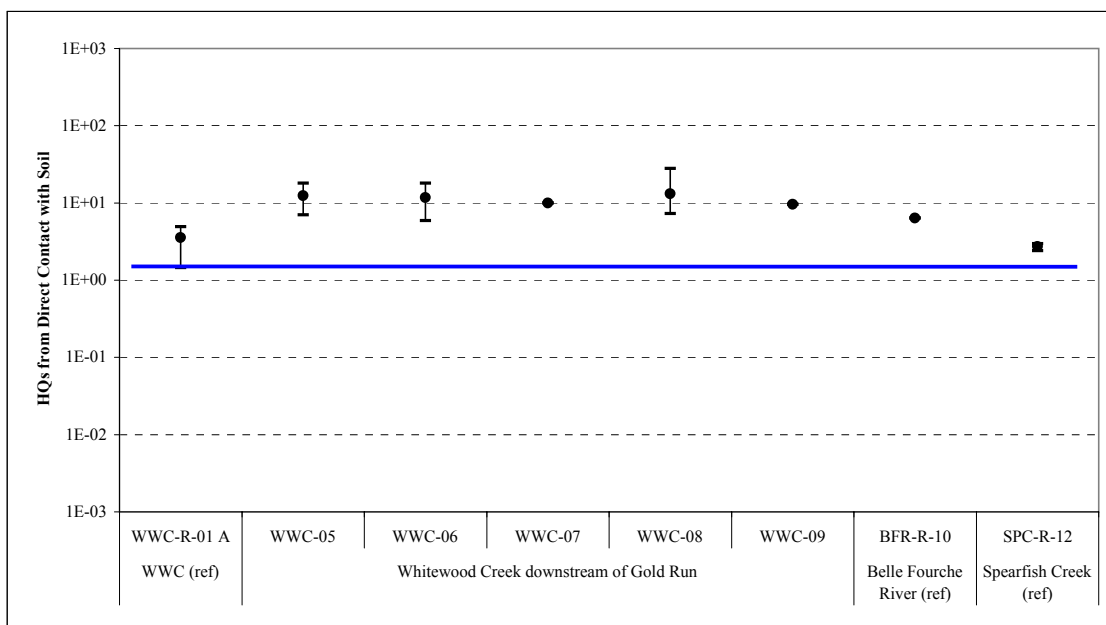


**LEGEND:**

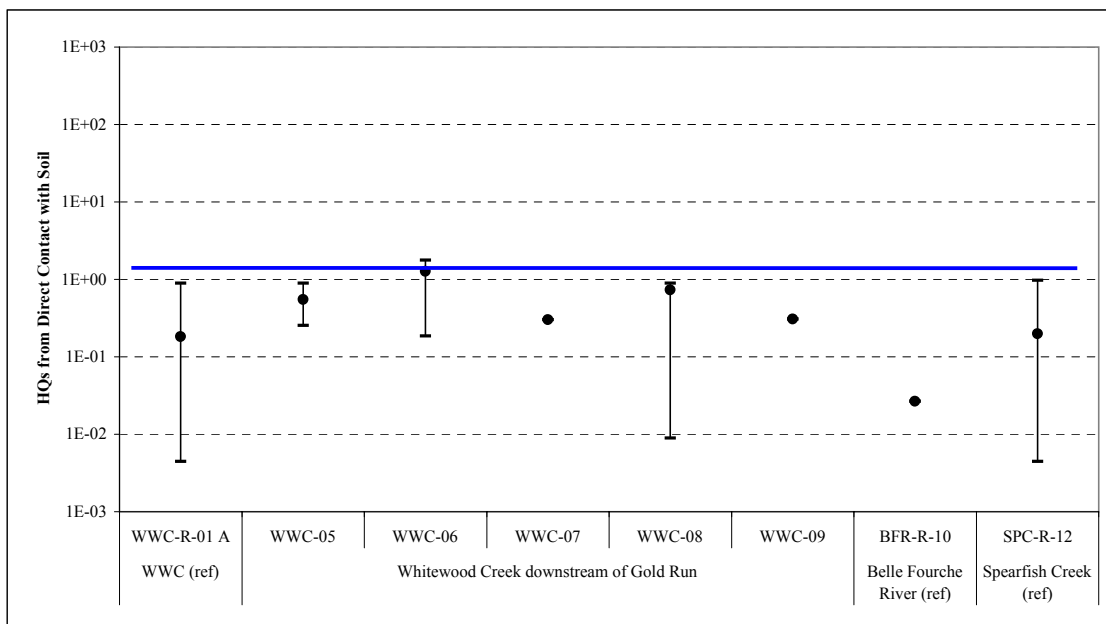


**Figure 7-2 (cont.)**  
**Calculation of HQs for Direct Contact of Soil Invertebrates with Soil**

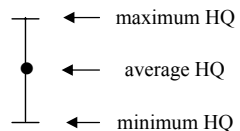
**MANGANESE**



**MERCURY**

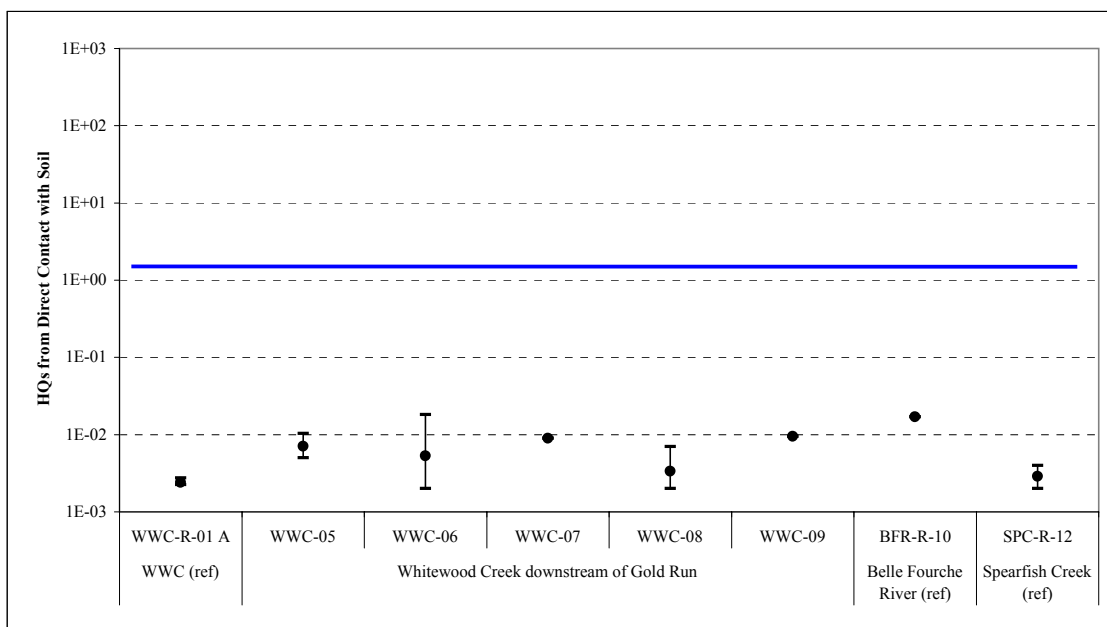


**LEGEND:**

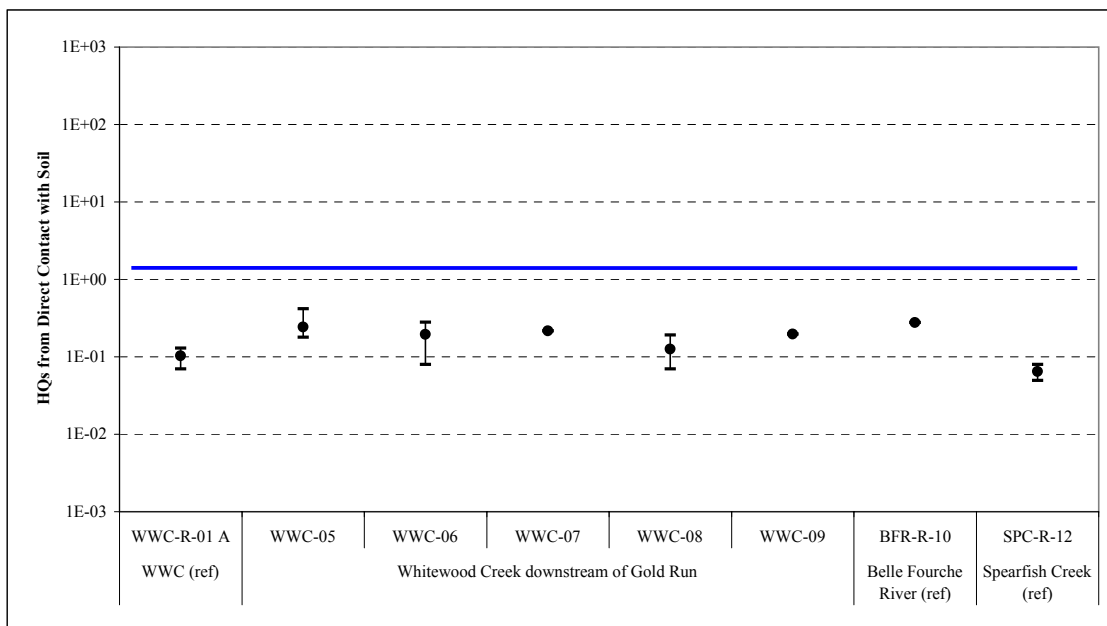


**Figure 7-2 (cont.)**  
**Calculation of HQs for Direct Contact of Soil Invertebrates with Soil**

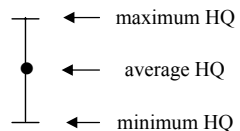
**MOLYBDENUM**



**NICKEL**

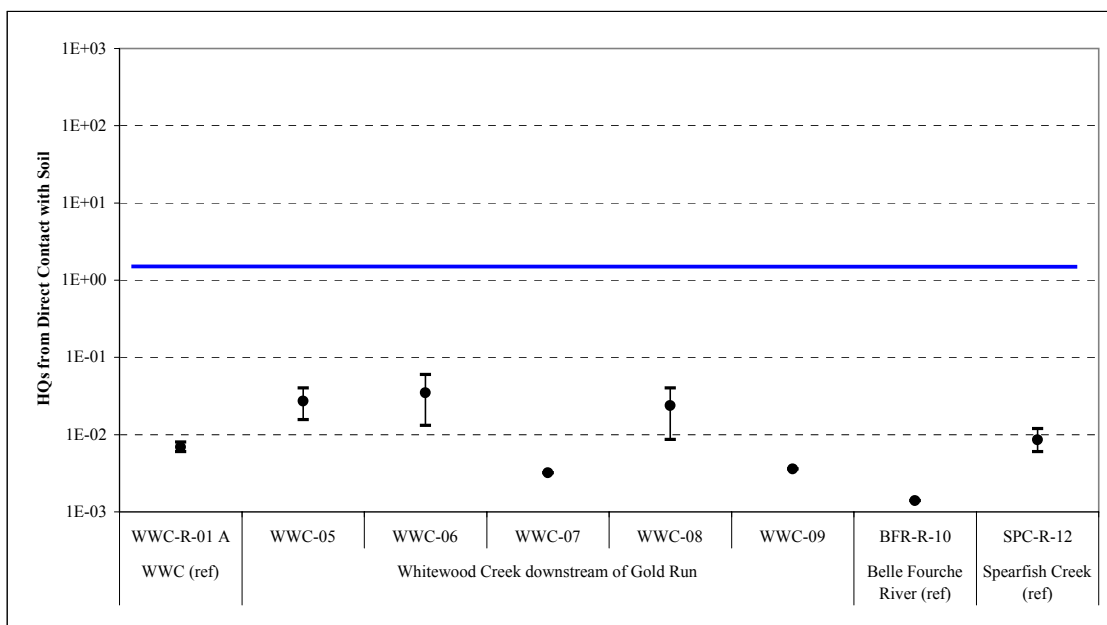


**LEGEND:**

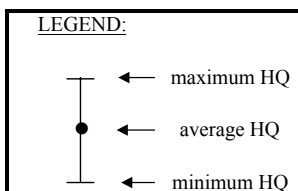
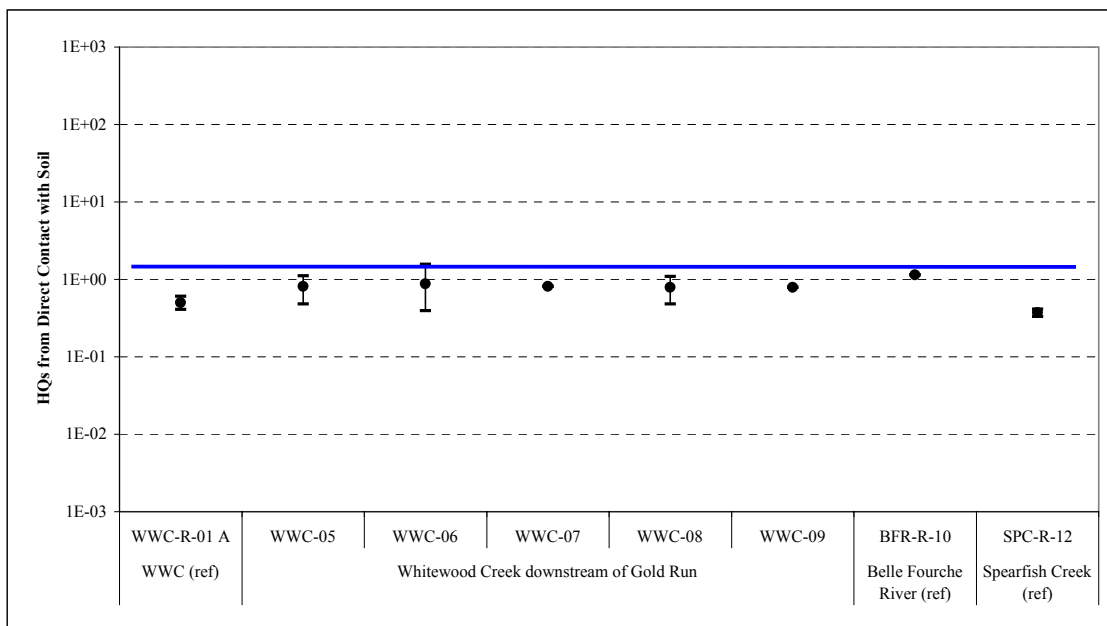


**Figure 7-2 (cont.)**  
**Calculation of HQs for Direct Contact of Soil Invertebrates with Soil**

**SILVER**

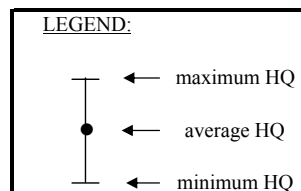
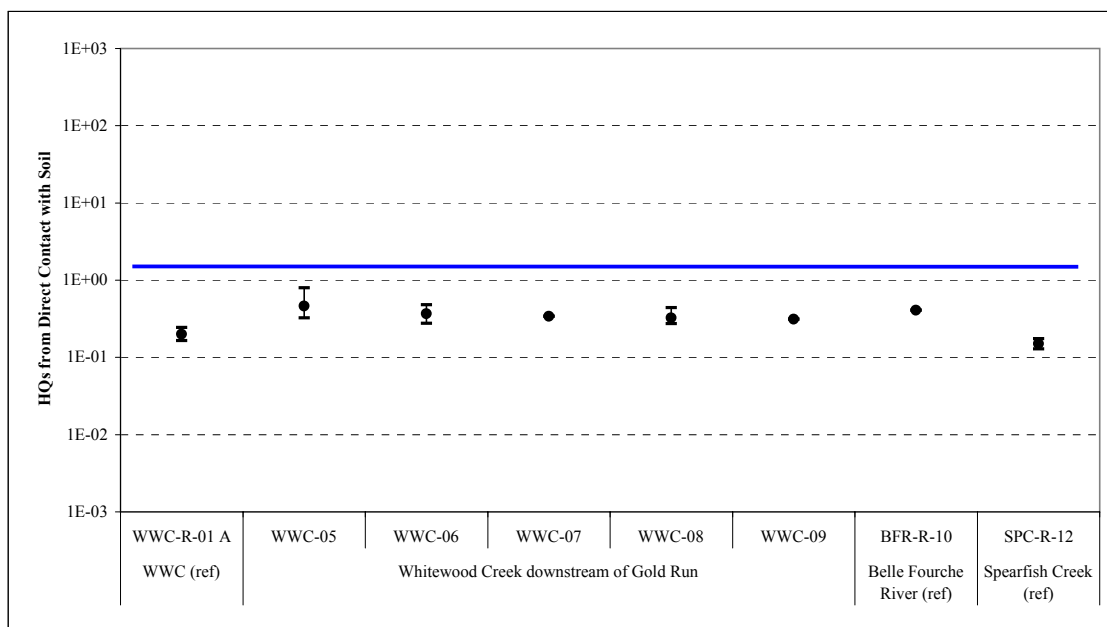


**VANADIUM**



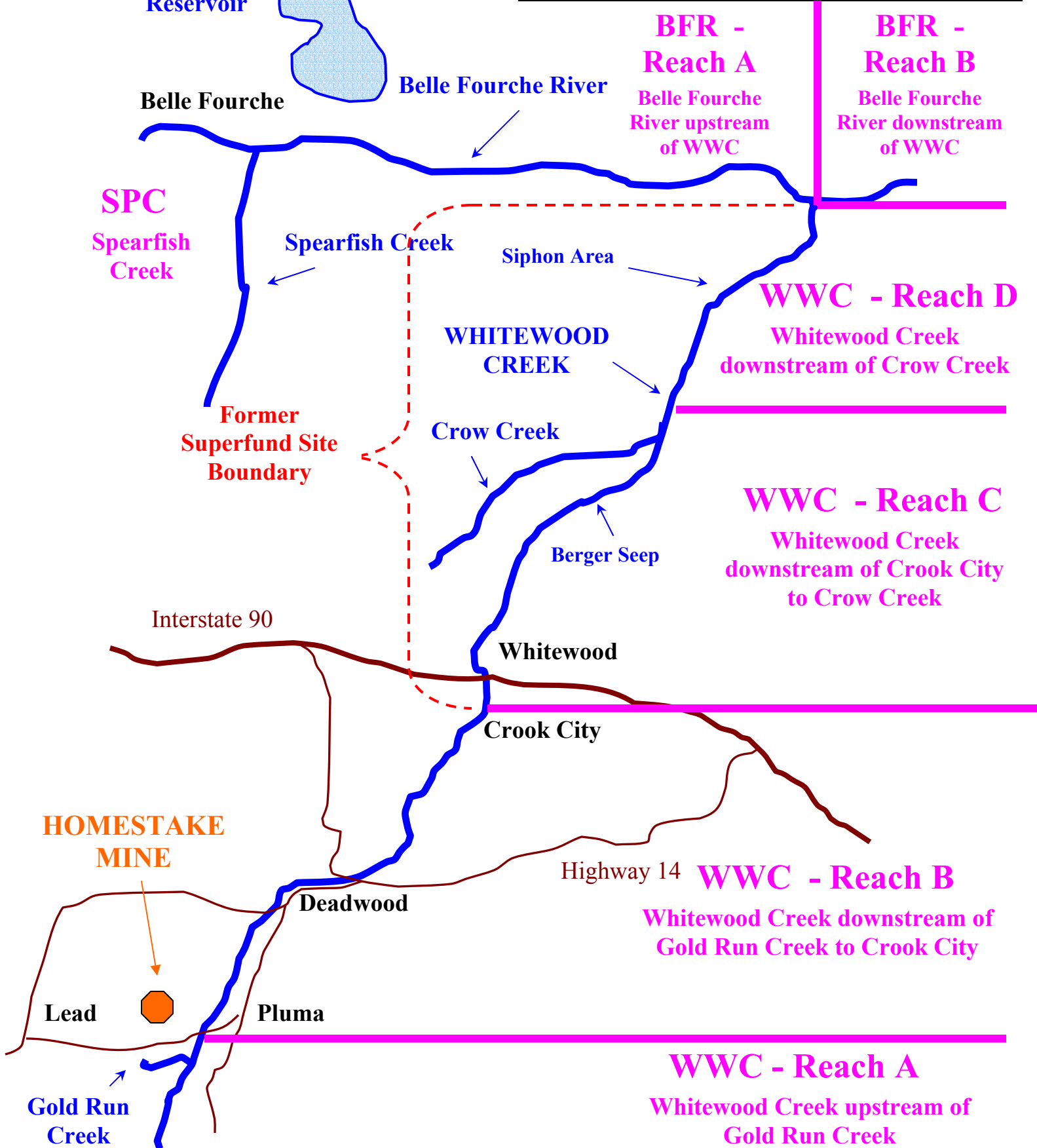
**Figure 7-2 (cont.)**  
**Calculation of HQs for Direct Contact of Soil Invertebrates with Soil**

**ZINC**



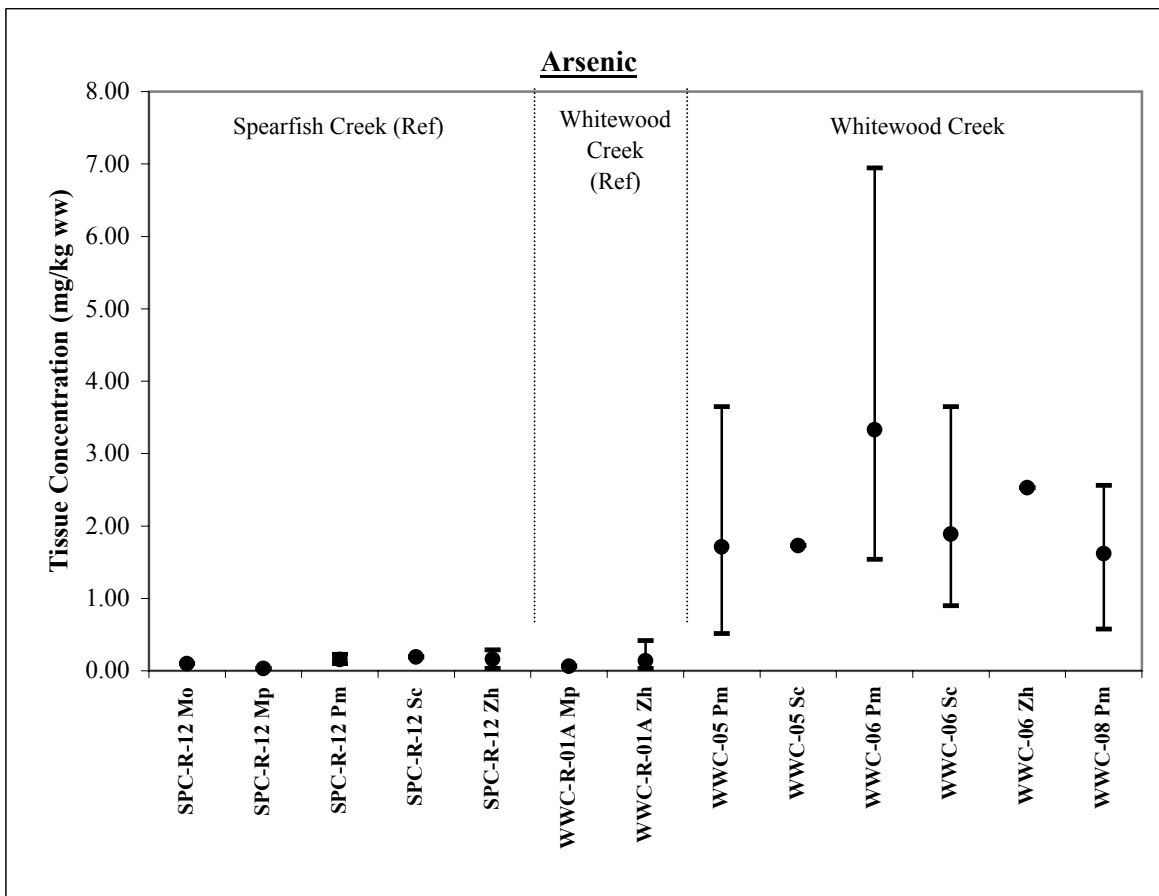
**Figure 8-1**  
**Wildlife Exposure Reach Map**

*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*



**Figure 8-2**  
**Summary of Small Mammal Tissue Concentrations by Location**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*



Species:

- Mo - Prairie Vole (*Microtus ochrogaster*)  
 Mp - Meadow Vole (*Microtus pennsylvanicus*)  
 Pm - Deer Mouse (*Peromyscus maniculatus*)  
 Sc - Masked Shrew (*Sorex cinereus*)  
 Zh - Meadow Jumping Mouse (*Zapus hudsonius*)

Legend:




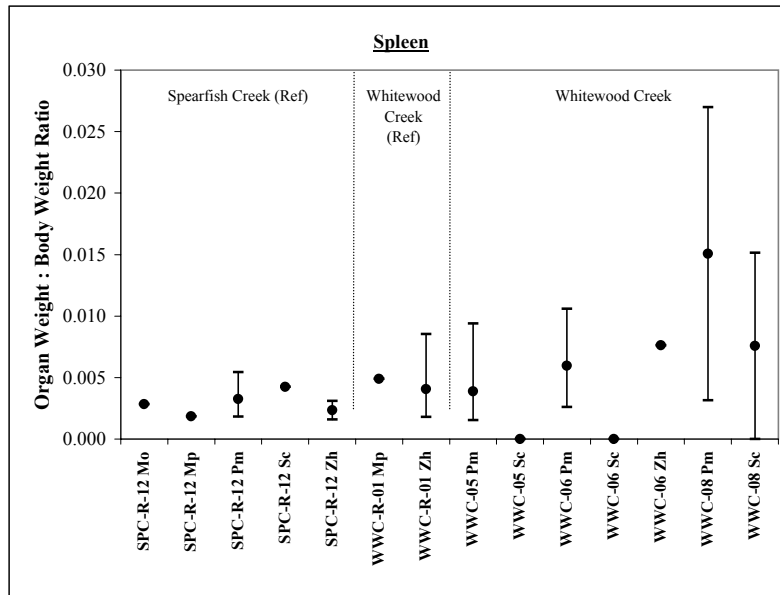
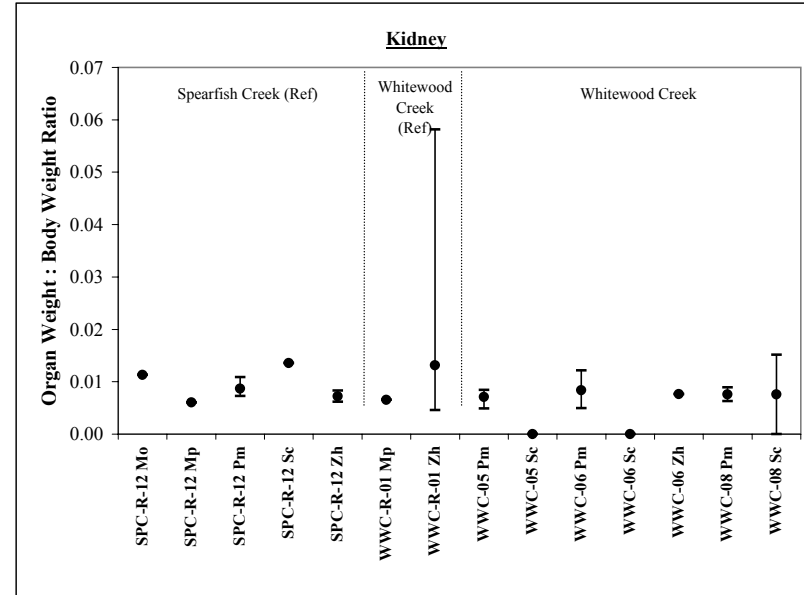
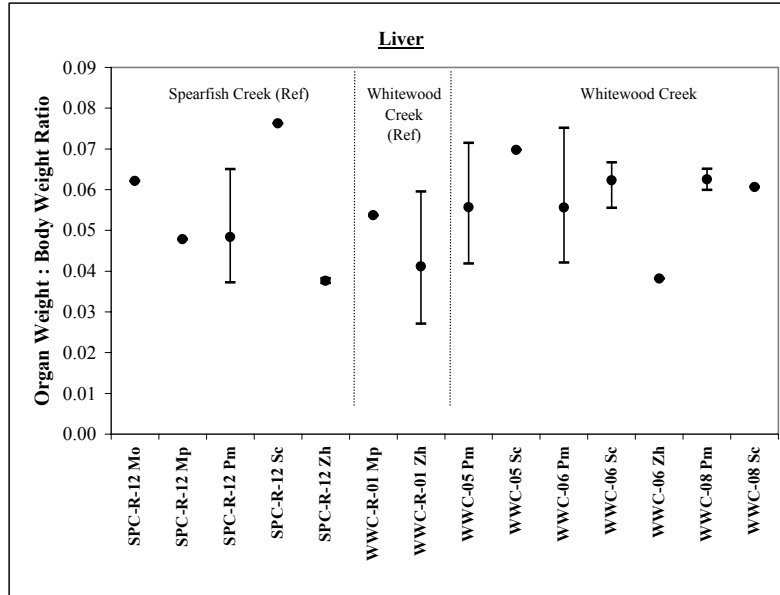
-  ← Maximum Conc  
 ← Average Conc  
 ← Minimum Conc

Figure 8-3  
Summary of Small Mammal Organ Weight Ratios by Location

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*



Species:

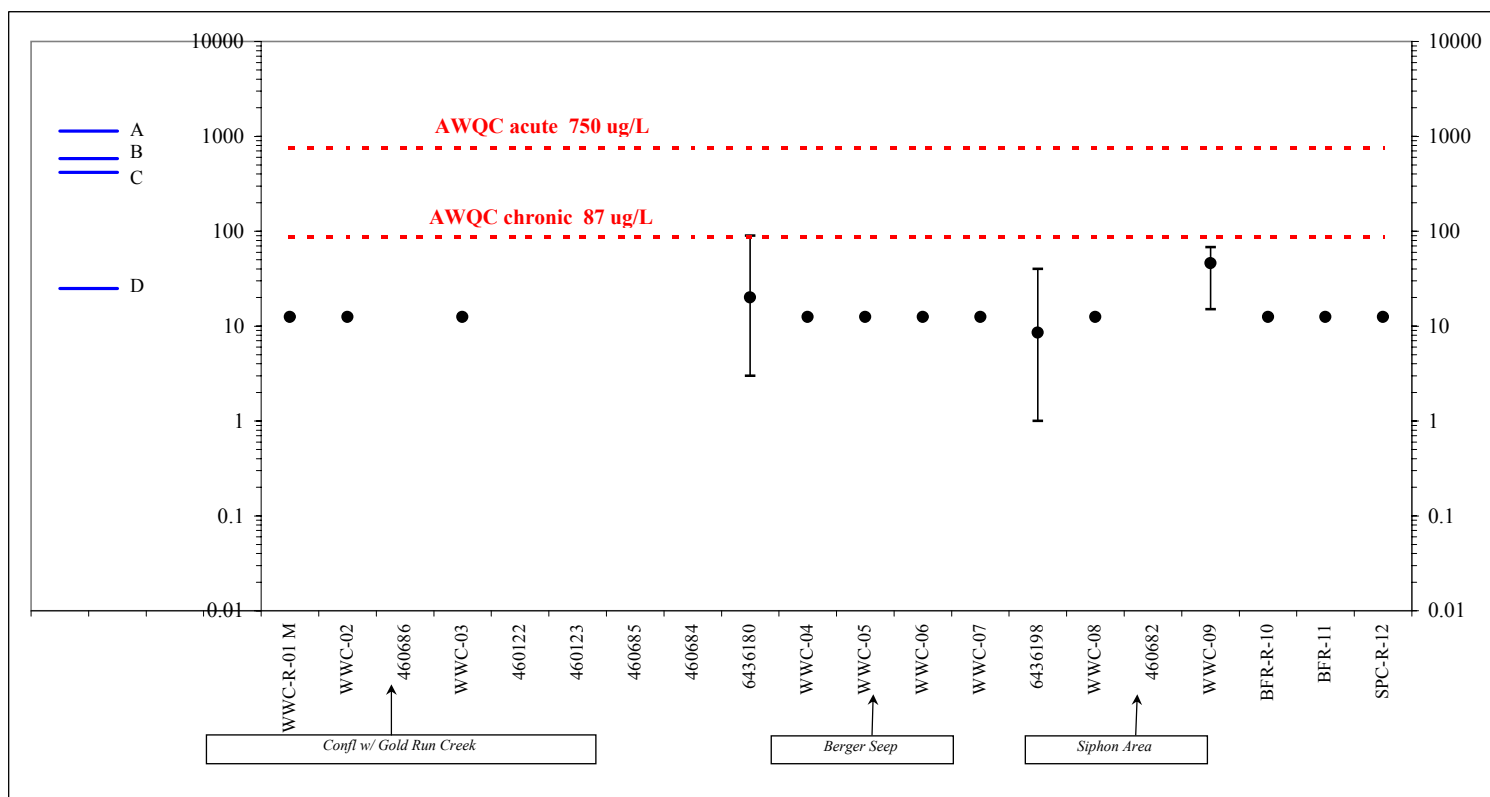
- Mo - Prairie Vole (*Microtus ochrogaster*)  
 Mp - Meadow Vole (*Microtus pennsylvanicus*)  
 Pm - Deer Mouse (*Peromyscus maniculatus*)  
 Sc - Masked Shrew (*Sorex cinereus*)  
 Zh - Meadow Jumping Mouse (*Zapus hudsonius*)

Legend:

- ← Maximum  
 ● Average  
 ← Minimum

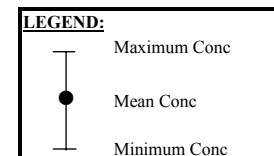
**Figure 9-1a. Comparison of Dissolved Aluminum Concentrations in Surface Water  
with Acute TRVs for Amphibians**

*Ecological Risk Assessment for Whitewood Creek, Lead, South Dakota*



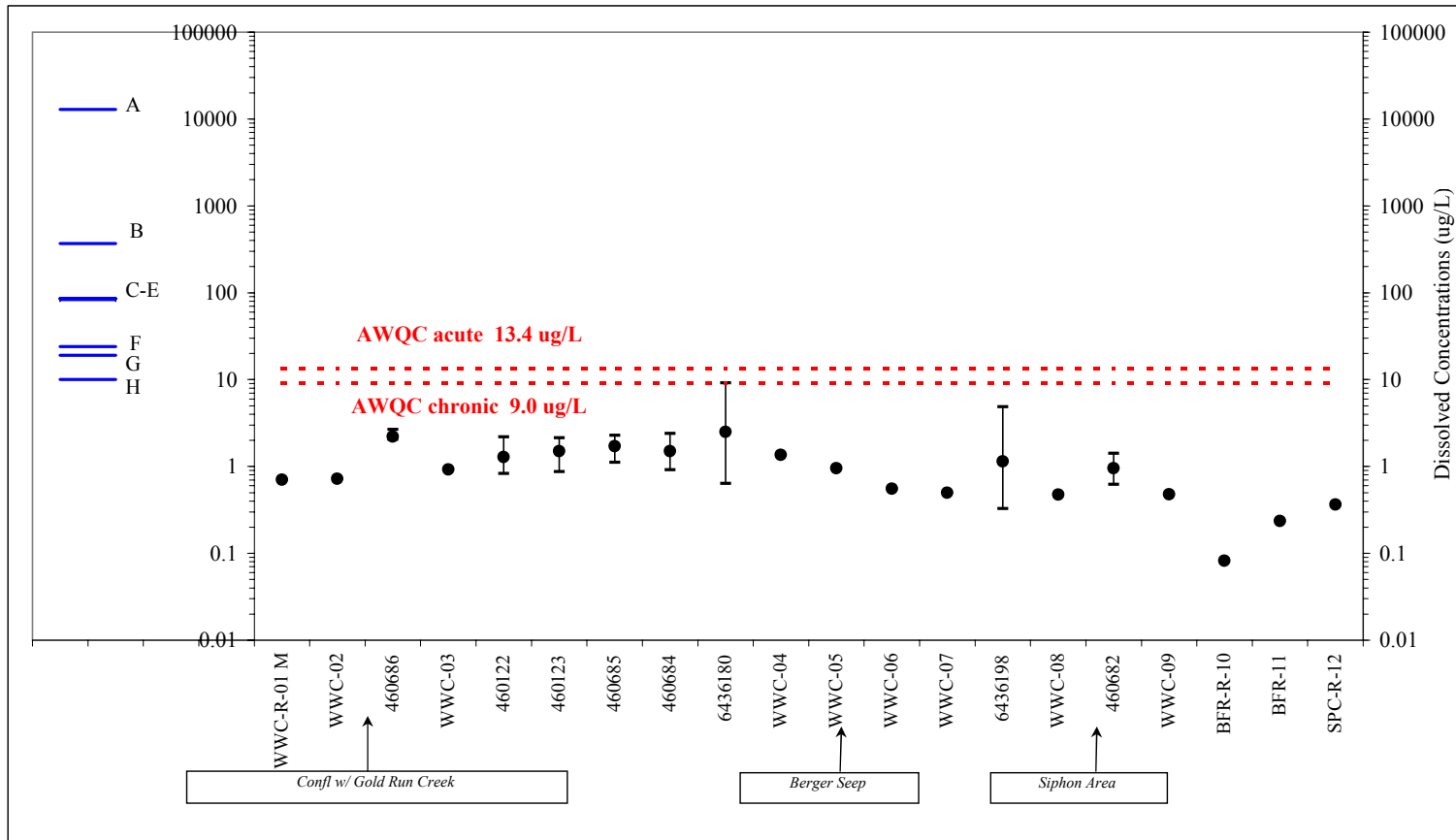
All surface water concentrations and TRVs are expressed in units of ug/L.  
All TRVs are based on LC50 for egg, embryo, or tadpole; TRV = LC50/2.

Acute TRV (ug/L)	Duration
A 1140 Marbled salamander (eggs)	192 hrs
B 584.1 American toad (tadpole)	96 hrs
C 416.8 Leopard frog (embryo)	96 hrs
D 25 Eastern Narrow-Mouthed Toad (eggs)	168 hrs



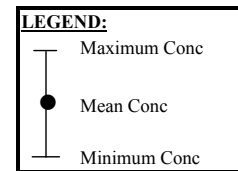
**Figure 9-1b. Comparison of Dissolved Copper Concentrations in Surface Water  
with Acute TRVs for Amphibians**

*Ecological Risk Assessment for Whitewood Creek, Lead, South Dakota*



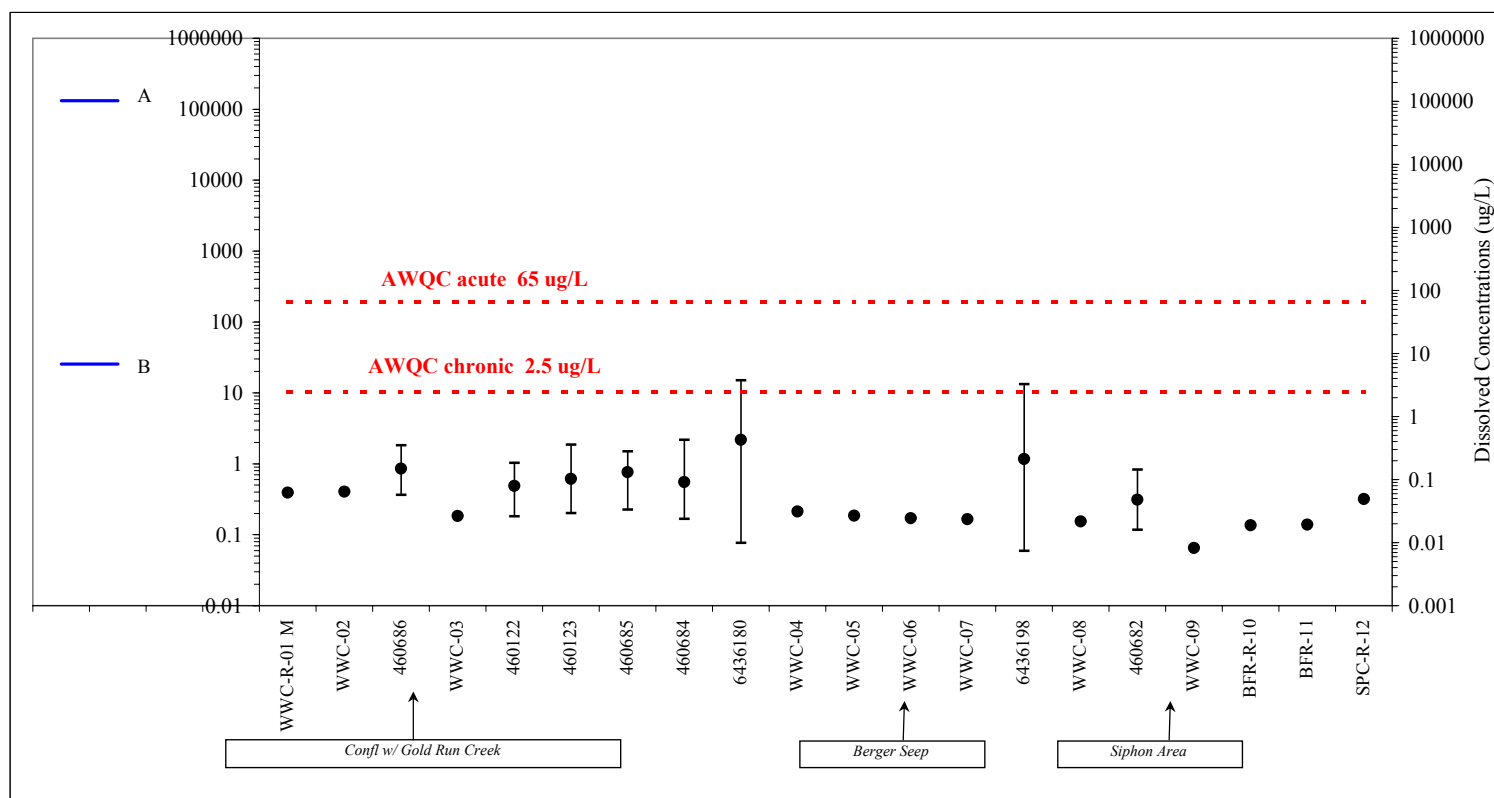
All surface water concentrations and TRVs are expressed in units of ug/L.  
All concentration values normalized to a hardness of 100mg/L.  
All TRVs are based on LC50 for egg, embryo, or tadpole; TRV = LC50/2.

Acute TRV (ug/L)			Duration
A	12,941	Fowler's toad (eggs)	168 hrs
B	370	Marbled salamander (eggs)	192 hrs
C	86	Common Indian toad (2 cm, 100 mg)	96 hrs
D	85	Frog (tadpole/20 mm, 500 mg)	96 hrs
E	82	Tiger frog, Indian bullfrog (larva)	96 hrs
F	24	Leopard frog (eggs)	192 hrs
G	19	Southern grey tree frog (eggs)	168 hrs
H	10	Eastern Narrow-Mouthed Toad (eggs)	168 hrs



**Figure 9-1c. Comparison of Dissolved Lead Concentrations in Surface Water  
with Acute TRVs for Amphibians**

*Ecological Risk Assessment for Whitewood Creek, Lead, South Dakota*



All surface water concentrations and TRVs are expressed in units of ug/L.

All concentration values normalized to a hardness of 100mg/L.

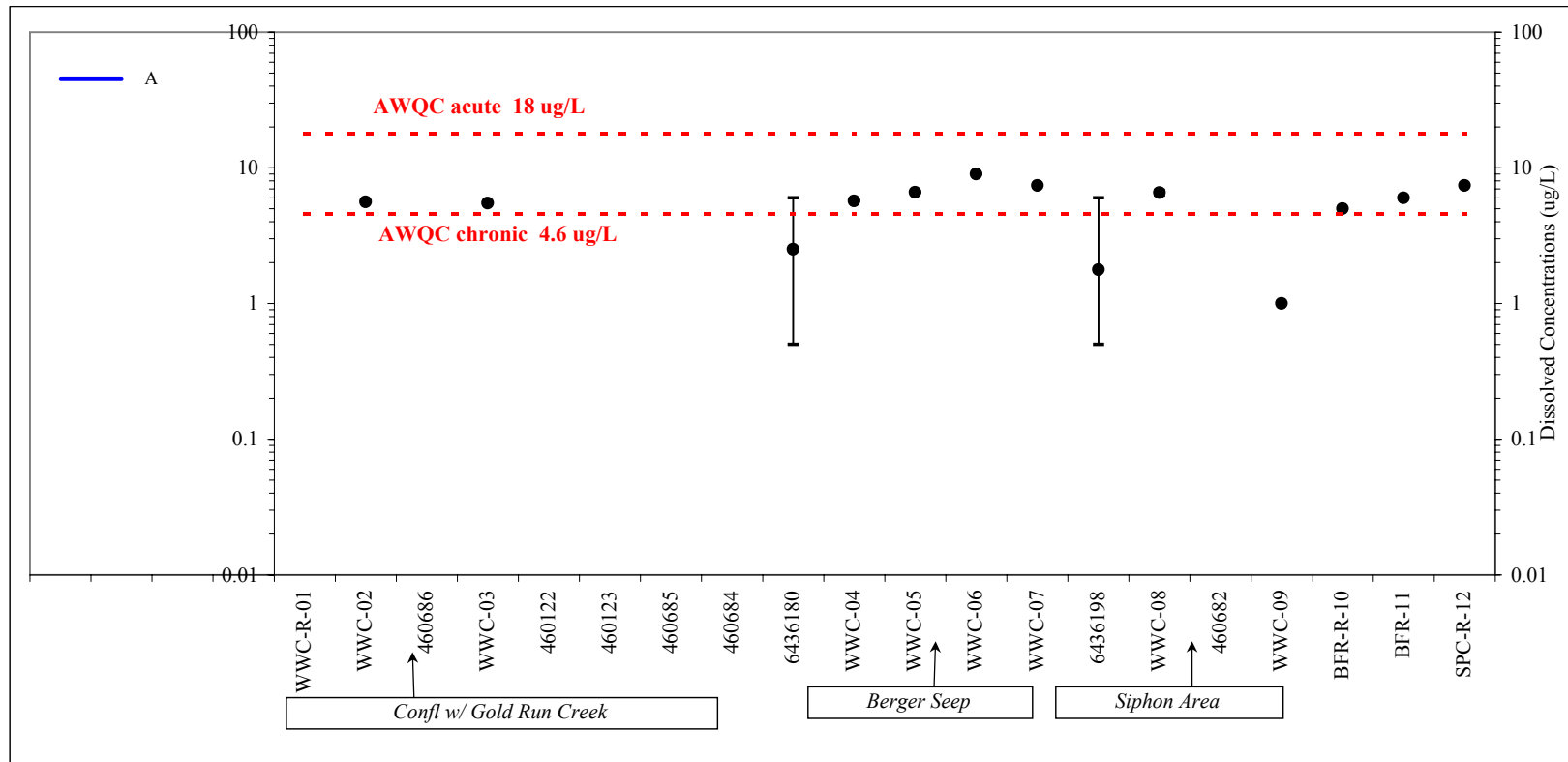
All TRVs are based on LC50 for egg, embryo, or tadpole; TRV = LC50/2.

Acute TRV (ug/L)		Duration
A	102,122 Frog (20 mm, 500 mg)	96 hrs
B	6.8 Eastern Narrow-Mouthed Toad (eggs)	168 hrs

LEGEND:	
	Maximum Conc
	Mean Conc
	Minimum Conc

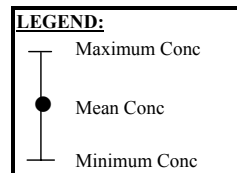
**Figure 9-1d. Comparison of Dissolved Selenium Concentrations in Surface Water  
with Acute TRVs for Amphibians**

*Ecological Risk Assessment for Whitewood Creek, Lead, South Dakota*



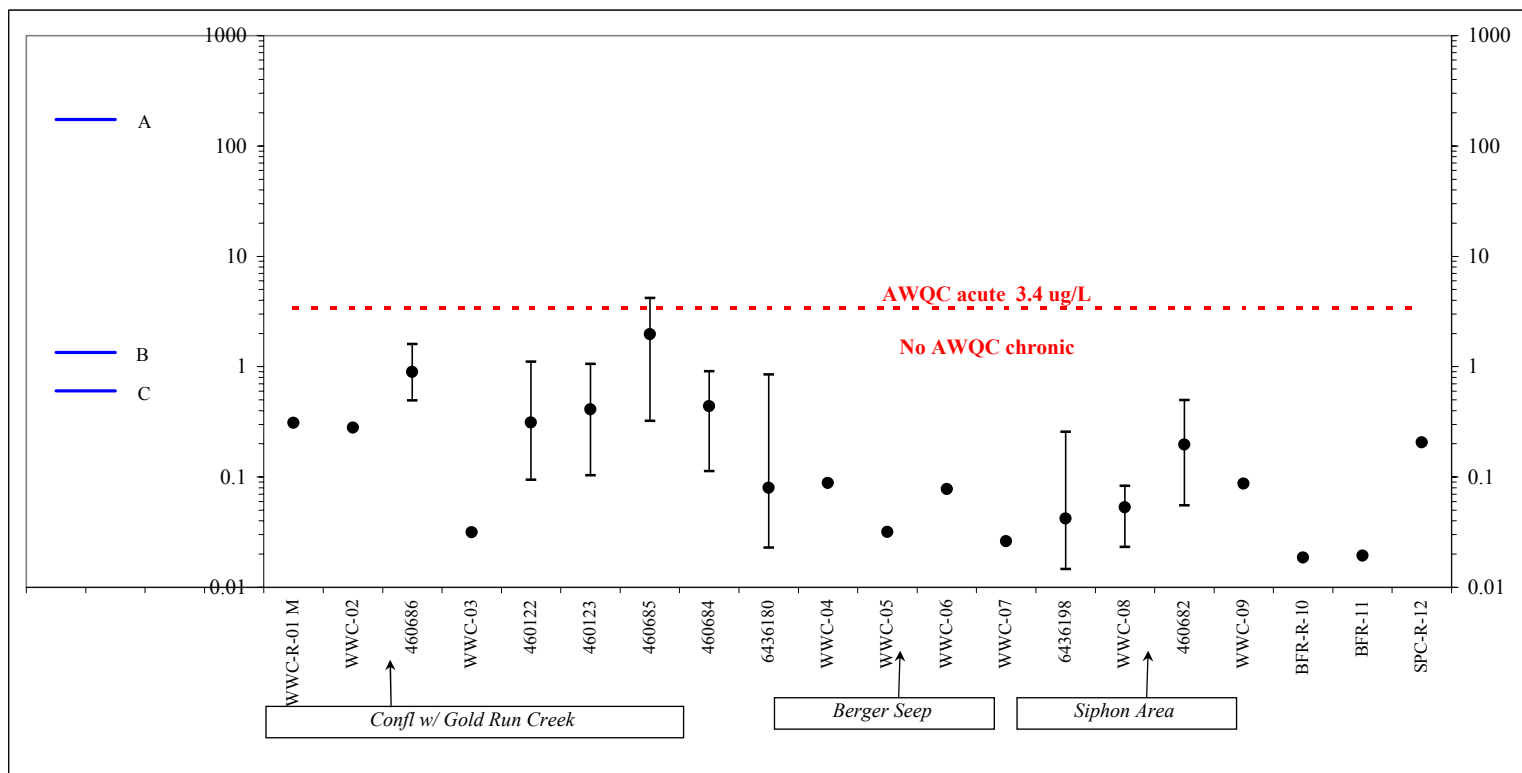
All surface water concentrations and TRVs are expressed in units of ug/L.  
All TRVs are based on LC50 for egg, embryo, or tadpole; TRV = LC50/2.

Acute TRV (ug/L)			Duration
A	45	Eastern Narrow-Mouthed Toad (eggs)	168 hrs



**Figure 9-1e. Comparison of Dissolved Silver Concentrations in Surface Water with Acute TRVs for Amphibians**

*Ecological Risk Assessment for Whitewood Creek, Lead, South Dakota*



All surface water concentrations and TRVs are expressed in units of ug/L.

All concentration values normalized to a hardness of 100mg/L.

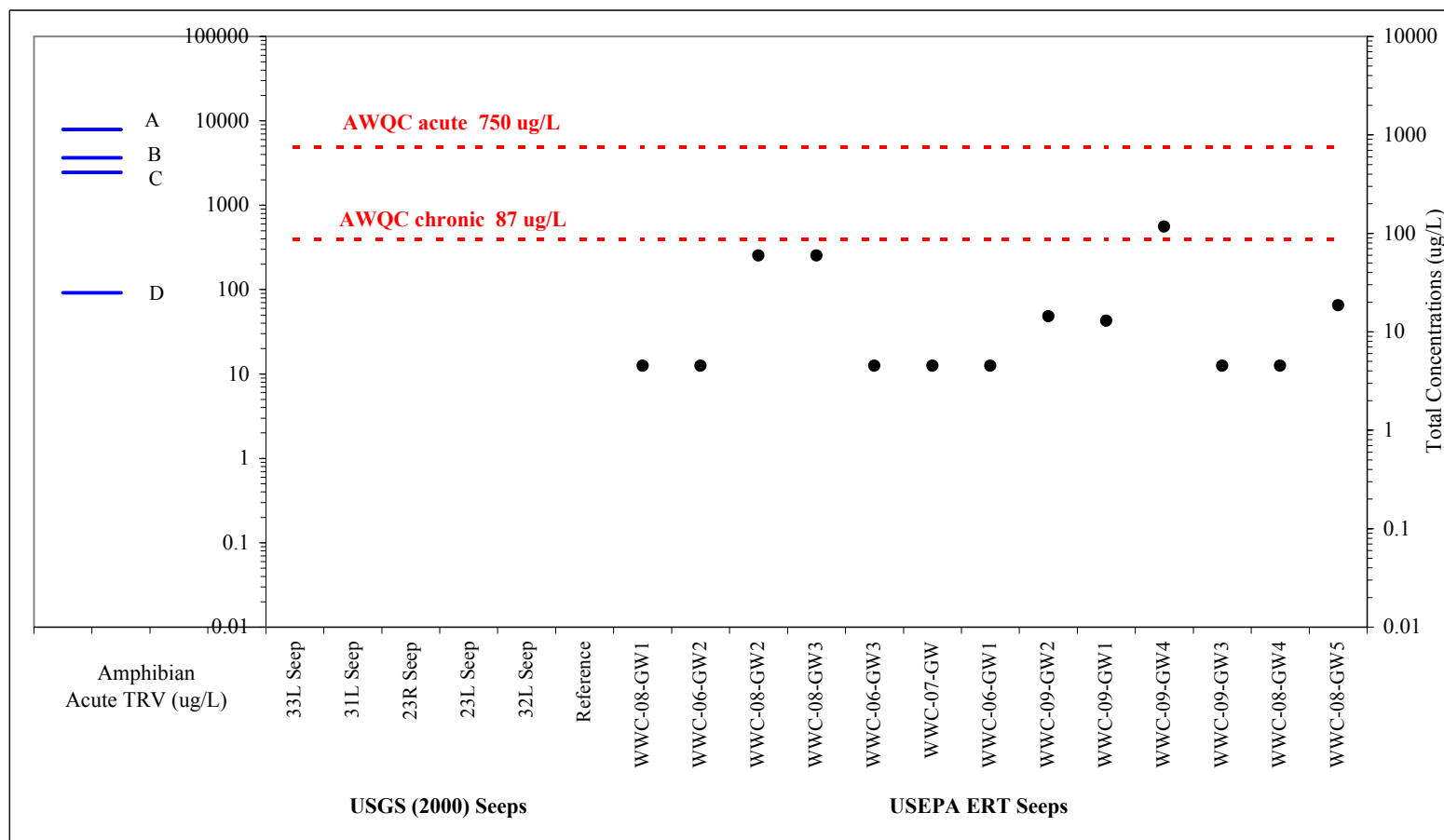
All TRVs are based on LC50 for egg, embryo, or tadpole; TRV = LC50/2.

Acute TRV (ug/L)		Duration
A	174 Frog (20 mm, 500 mg)	96 hrs
B	1.3 Eastern Narrow-Mouthed Toad (eggs)	168 hrs
C	0.6 Common indian toad (2 cm, 100 mg)	96 hrs

LEGEND:	
—	Maximum Conc
●	Mean Conc
—	Minimum Conc

**Figure 9-2a. Comparison of Total Aluminum Concentrations in Seep Water  
with Acute TRVs for Amphibians**

*Ecological Risk Assessment for Whitewood Creek, Lead, South Dakota*



All seep water concentrations and TRVs are expressed in units of ug/L.  
All TRVs are based on LC50 for egg, embryo, or tadpole; TRV = LC50/2.

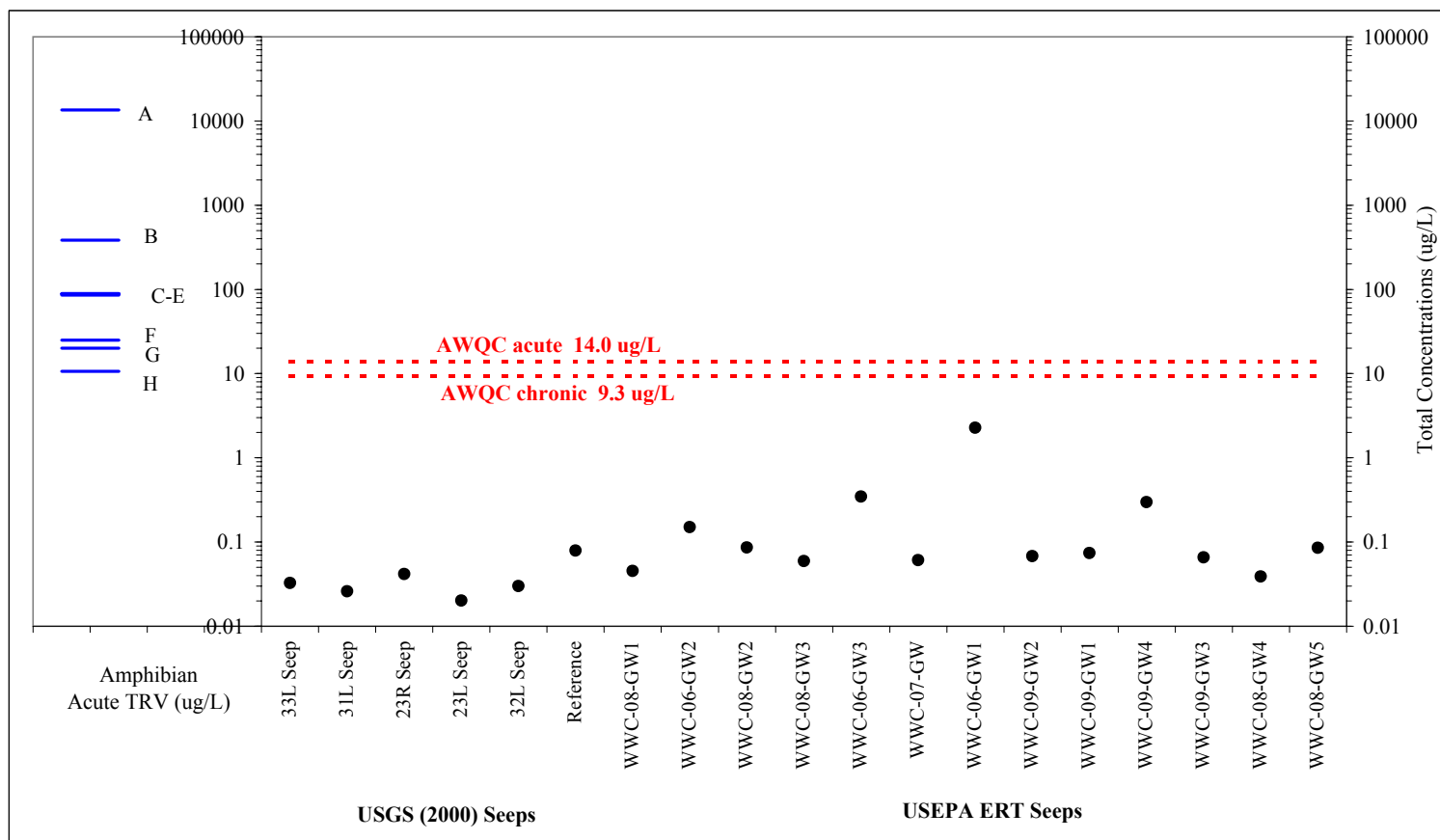
Acute TRV (ug/L)			Duration
A	1140	Marbled salamander (eggs)	192 hrs
B	584.14	American toad (tadpole)	96 hrs
C	416.82	Leopard frog (embryo)	96 hrs
D	25	Eastern Narrow-Mouthed Toad (eggs)	168 hrs

**LEGEND:**

● Measured Conc

**Figure 9-2b. Comparison of Total Copper Concentrations in Seep Water  
with Acute TRVs for Amphibians**

*Ecological Risk Assessment for Whitewood Creek, Lead, South Dakota*



All seep water concentrations and TRVs are expressed in units of ug/L.

All concentration values normalized to a hardness of 100mg/L.

All TRVs are based on LC50 for egg, embryo, or tadpole; TRV = LC50/2.

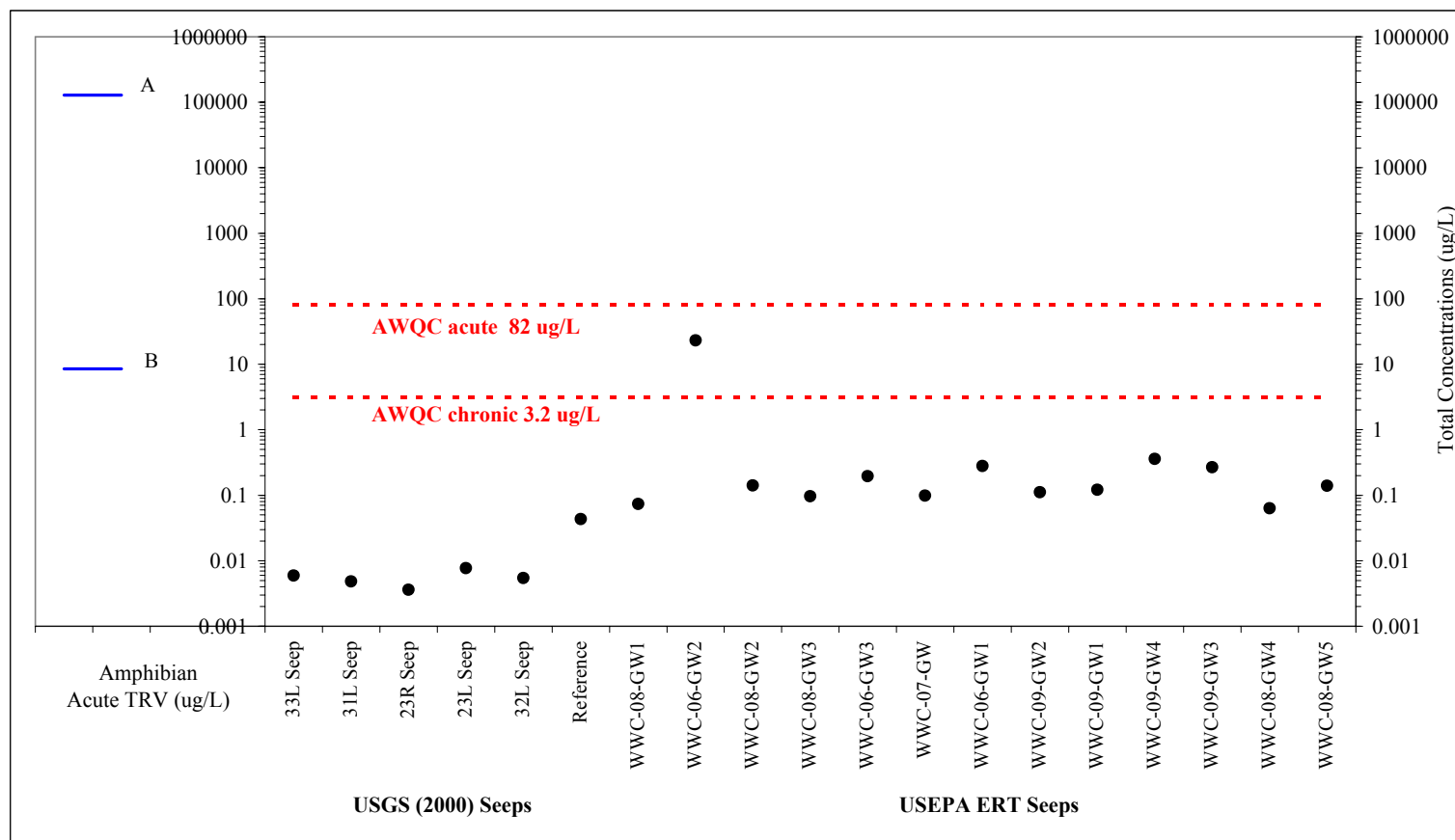
Acute TRV (ug/L)			Duration
A	13,480	Fowler's toad (eggs)	168 hrs
B	385	Marbled salamander (eggs)	192 hrs
C	90	Common Indian toad (2 cm, 100 mg)	96 hrs
D	89	Frog (tadpole/20 mm, 500 mg)	96 hrs
E	85	Tiger frog, Indian bullfrog (larva)	96 hrs
F	25	Leopard frog (eggs)	192 hrs
G	20	Southern grey tree frog (eggs)	168 hrs
H	11	Eastern Narrow-Mouthed Toad (eggs)	168 hrs

**LEGEND:**

● Measured Conc

**Figure 9-2c. Comparison of Total Lead Concentrations in Seep Water  
with Acute TRV's for Amphibians**

*Ecological Risk Assessment for Whitewood Creek, Lead, South Dakota*



All seep water concentrations and TRVs are expressed in units of ug/L.

All concentration values normalized to a hardness of 100mg/L.

All TRVs are based on LC50 for egg, embryo, or tadpole; TRV = LC50/2.

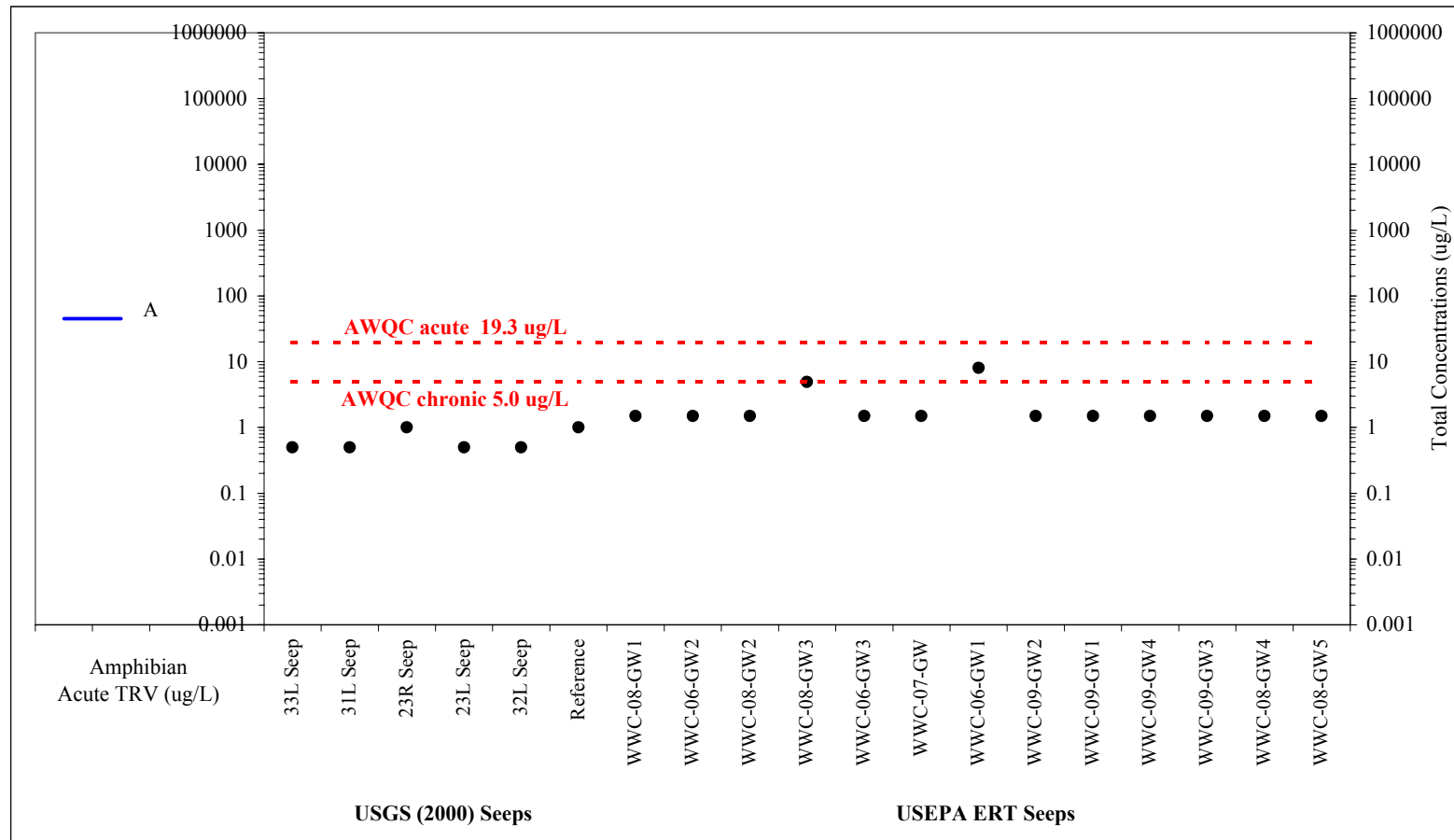
Acute TRV (ug/L)			Duration
A	129,105	Frog (20 mm, 500 mg)	96 hrs
B	9	Eastern Narrow-Mouthed Toad (eggs)	168 hrs

**LEGEND:**

● Measured Conc

**Figure 9-2d. Comparison of Total Selenium Concentrations in Seep Water  
with Acute TRV's for Amphibians**

*Ecological Risk Assessment for Whitewood Creek, Lead, South Dakota*



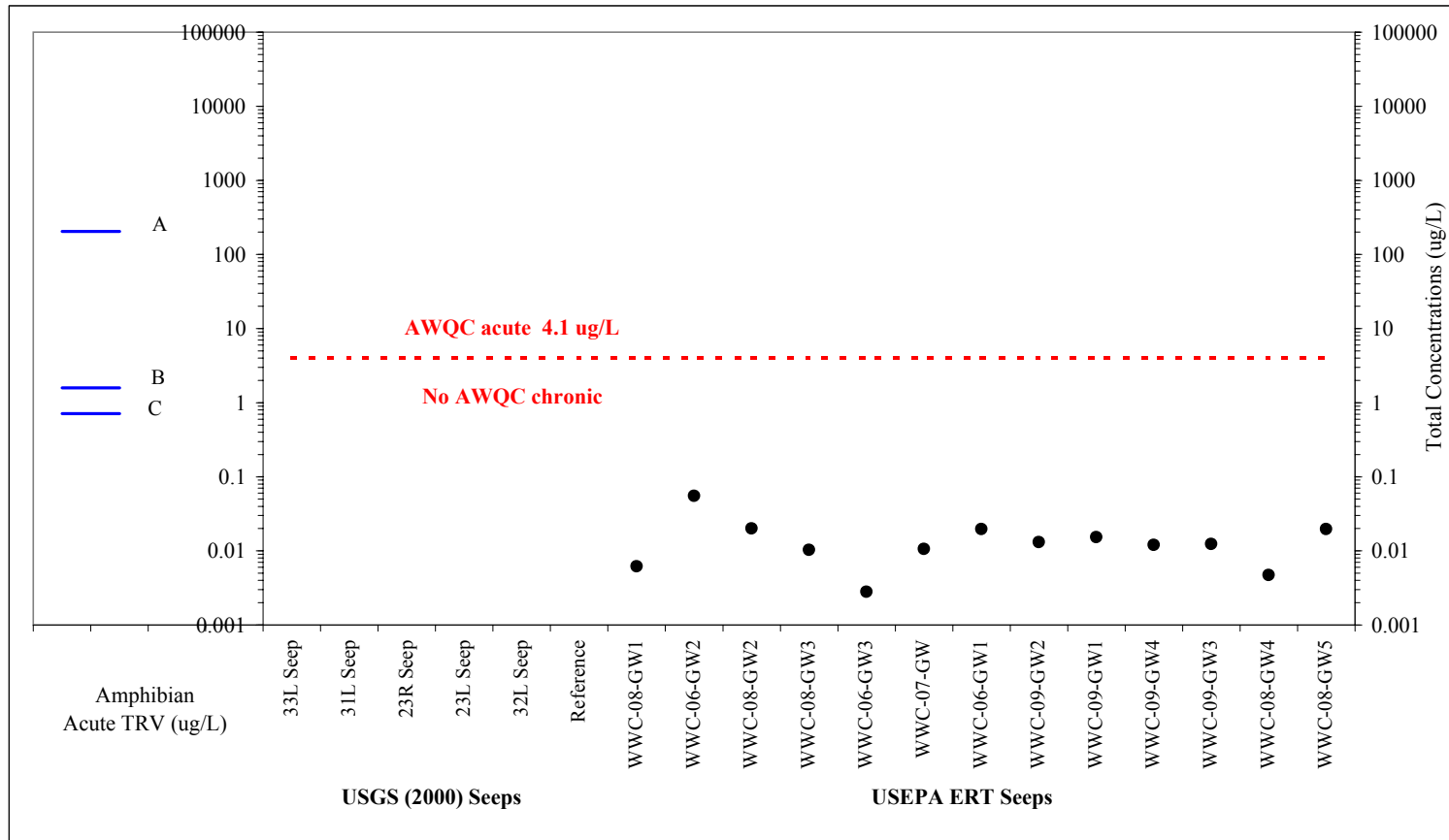
All seep water concentrations and TRVs are expressed in units of ug/L.  
All TRVs are based on LC50 for egg, embryo, or tadpole; TRV = LC50/2.

Acute TRV (ug/L)			Duration
A	45	Eastern Narrow-Mouthed Toad (eggs)	168 hrs

**LEGEND:**  
● Measured Conc

**Figure 9-2e. Comparison of Total Silver Concentrations in Seep Water  
with Acute TRV's for Amphibians**

*Ecological Risk Assessment for Whitewood Creek, Lead, South Dakota*



All seep water concentrations and TRVs are expressed in units of ug/L.

All concentration values normalized to a hardness of 100mg/L.

All TRVs are based on LC50 for egg, embryo, or tadpole; TRV = LC50/2.

Acute TRV (ug/L)			Duration
A	205	Frog (20 mm, 500 mg)	96 hrs
B	1.6	Eastern Narrow-Mouthed Toad (eggs)	168 hrs
C	0.7	Common indian toad (2 cm, 100 mg)	96 hrs

**LEGEND:**

● Measured Conc

**-FINAL-  
ECOLOGICAL RISK ASSESSMENT  
WHITEWOOD CREEK SITE FIVE YEAR REVIEW  
LEAD, SOUTH DAKOTA**

**July 2002**

**Tables**

**Table 2-1**  
**Timeline of Events and Reports**

***Ecological Risk Assessment***  
***Whitewood Creek Site, Lead, South Dakota***

<b>Date</b>	<b>Description of Event and Reports</b>
1877-1977	Operation of Homestake Mine with tailings being discharged directly to Gold Run Creek and Whitewood Creek (USEPA, 1990).
1960	South Dakota Department of Health quantifies solids and cyanide loading to Whitewood Creek (USEPA, 1990).
1965	SD Department of Game Fish and Parks (SDGFP) identified that aquatic bottom organisms were absent in Whitewood Creek downstream from the waste discharges (USEPA, 1990).
1970-71	Series of studies by EPA, FDA and University of SD to document magnitude and extent of tailings. Focused on the environmental hazards associated with mercury. Led to discontinuance of the use of the mercury amalgamation process by HMC (USEPA, 1990).
1970	<u>December</u> . Use of mercury amalgamation discontinued (USEPA, 1990).
1974-75	50 Holstein cattle adjacent to creek die of unknown causes. Study by the SD State University Dept. of Veterinary Science concluded that cattle died of arsenic toxicosis due to consumption of corn silage contaminated by accidental incorporation of mining wastes with fodder (USEPA, 1990).
1975-78	Joint study by SD Geological Survey and the USGS Water Resources Division investigated the presence of arsenic in surface and groundwaters of Whitewood Creek, the Belle Fourche River and the Cheyenne River (USEPA, 1990).
1977	<u>December</u> . Implementation of the Grizzly Gulch Tailings Disposal project. This tailings disposal system ended the direct discharge of tailings to Whitewood Creek (USEPA, 1990).
1981	<u>September</u> . Whitewood Creek Site placed on interim NPL at the request of the governor of SD. EPA sends notice letter to HMC of potential liability (USEPA, 1990).
1982	EPA, SD Department of Water and Natural Resources (DWRN) and HMC entered into a three-party study agreement (memorandum of understanding) to conduct a comprehensive study. The study was funded by HMC and conducted by Fox Consultants under the supervision of a project advisory committee composed of representatives of the three parties.
1982	Bioassessment of Whitewood Creek completed for HMC (Herrick, 1982).
1983	<u>September 8</u> . Whitewood Creek Site placed on the NPL (USEPA, 1990).
1983	Request submitted to EPA by HMC to delete Whitewood Creek from NPL (USEPA, 1990).
1984	<u>December</u> . Multi-volume study released (Fox Consultants, 1984a, 1984b and 1984c).
1984	Wastewater treatment plant comes on-line. The untreated discharge of effluent from tailings pond to Whitewood Creek ceases.
1985	Draft report issued by USGS on an extensive investigation of surface water in Whitewood Creek initiated in 1982 (USGS, 1985). The report entitled <i>Composition, Distribution, and Hydrologic Effects of Mine and Mill Wastes Discharged to Whitewood Creek at Lead/Deadwood, South Dakota</i> was later replaced by USGS (1988).

**Table 2-1 (cont.)**  
**Timeline of Events and Reports**

***Ecological Risk Assessment***  
***Whitewood Creek Site, Lead, South Dakota***

<b>Date</b>	<b>Description of Event and Reports</b>
1985	<u>April</u> . Report completed by Environ Corp. entitled <i>Assessment of Exposure and Possible Effects on Human Health of Gold Mine Tailings in the Whitewood Creek Area of SD</i> . Written to support petition for delisting.
1985	Second petition for delisting submitted by HMC (USEPA, 1990). The delisting petition was rejected by EPA as being premature (USEPA, 1990).
1986	<i>Hydrogeochemistry of Sulfide and Arsenic Rich Tailings and Alluvium along Whitewood Creek, South Dakota</i> published in Mineral and Energy Resources. This work was completed by a group of consultants led by J.A. Cherry for HMC (USEPA, 1990).
1988	<u>January</u> . The first draft of the EA was completed by Battelle Pacific Northwest Laboratory for EPA (USEPA, 1990). Comments on the draft EA were provided by HMC to EPA in April 1988 (HMC, 1988).
1988	<u>March</u> . Report issued by Industrial Waste Management, Ltd. for HMC entitled An Evaluation of Aquatic Life Impacts Presented in the Draft Battelle Whitewood Creek Endangerment Assessment. Written in response to results of Whitewood Creek Study Phase II (Fox Consultants, Inc., 1984b) and draft EA (January 1988). Contains review of conclusions regarding aquatic life (surface water).
1988	<u>March</u> . A study entitled <i>Aging of Tailings Deposits by Tree Ring Analysis</i> was completed for HMC. The study aged the tailings deposits by the age of trees growing in them (Batt, 1988).
1988	<u>March</u> . A report entitled <i>Selenium Sources, Occurrences, and Mobility along Whitewood Creek, South Dakota</i> was completed by Geochemical Engineering Incorporated for HMC. The report describes sources, occurrences and mobility of selenium in the Whitewood Creek Basin and provides an analysis of the selenium concentrations in water supply wells along Whitewood Creek (Geochemical Engineering Incorporated, 1988).
1988	<u>October</u> . Additional study by Geochemical Engineering, Inc. for HMC was completed that incorporated additional groundwater data and soil data. The population residing within the site was interviewed regarding drinking water intake and locally grown food crops. Water supply wells were also tested (USEPA, 1990).
1988	<u>December</u> . An Administrative Order on Consent was signed by EPA and HMC. This order concludes that the studies completed by Fox Consultants, Inc., (1984a, 1984b and 1984c) constituted the functional equivalent of a remedial investigation, as prescribed by the National Contingency (NCP). The order required that HMC conduct a Feasibility Study (FS) to identify and evaluate alternatives for remedial action (USEPA, 1990).
1989	Report issued by USGS entitled <i>Composition, Distribution and Hydrologic Effects of Contaminated Sediments Resulting from the Discharge of Gold Milling Wastes to Whitewood Creek at Lead and Deadwood, South Dakota</i> (USGS, 1989) replacing USGS (1985).
1989	<u>March</u> . The second draft of the EA was released by EPA in March 1989 (USEPA, 1989a) and commented on by HMC in June 1989 (USEPA, 1990).
1989	<u>May</u> . Memo to Fred Fox from T.I. Mudder of Stefen Robertson and Kirsten Consulting Engineers on the <i>Impact of High Flow Events on the Potential for Exceedance of Aquatic Life Criteria for Arsenic</i> (Mudder, 1989). The memo discusses the impact of high flow events on the potential for exceedance of aquatic life criteria for arsenic. Written in response to concerns raised in the draft EPA EA (USEPA, 1989a).
1989	<u>May-June</u> . Wildlife Survey of Whitewood Creek completed by Harner & Associates on behalf of HMC in support of a mining permit application (Harner & Associates, 1990a).
1989	<u>July</u> . Final EA was completed by EPA with the assistance of Jacobs Engineering (Jacobs, 1989).
1989	<u>December</u> . ICF Technology on behalf of HMC completed an FS (ICF, 1990).

**Table 2-1 (cont.)**  
**Timeline of Events and Reports**

***Ecological Risk Assessment***  
***Whitewood Creek Site, Lead, South Dakota***

<b>Date</b>	<b>Description of Event and Reports</b>
1989	Biological Survey of Whitewood Creek and the Belle Fourche River completed by Chadwick & Associates. Report issued in 1990 (Chadwick & Associates, 1990a).
1990	<u>January</u> . Administrative record established.
1990	<u>March</u> . Record of Decision (ROD) document issued (USEPA, 1990).
1990	Biological survey of Whitewood Creek completed in April 1990 (Chadwick & Associates, Inc., 1990b).
1990	Second year of baseline wildlife study completed by Harner & Associates for HMC (Harner & Associates, 1990b).
1991	Consent order entered by Federal District Court of South Dakota (Chadwick Ecological Consultants, Inc., 1997).
1991	<u>June</u> . Explanation of Significant Differences notice issued by USEPA. Written to explain differences between ROD and remedy to be implemented (USEPA, 1991).
1992	Applicable or Relevant and Appropriate Requirements (ARARs) Report issued (Chadwick Ecological Consultants, Inc., 1997)
1992	Remediation completed at 16 residences (Chadwick Ecological Consultants, Inc., 1997).
1993	USEPA Review of Whitewood Creek Superfund Site.
1996	Deletion of Whitewood Creek Site from NPL.
1996	Biological survey of Whitewood Creek completed (Knowles, 1996a) in support of partial fulfillment of a mining permit application. A breeding bird survey was also completed (Knowles, 1996b).
1997	<u>November</u> . Approximately 100 gallons of slurry were accidentally released from Kirk bore hole (15-20 mg/L cyanide) resulting in a fish kill in Whitewood Creek.
1997	<u>December</u> . Report issued entitled <i>Final Status Report and Technical Support Document for the 1997 5-Year Review</i> completed by Chadwick Ecological Consultants, Inc. for HMC (Chadwick Ecological Consultants, Inc., 1997).
1998	<u>May</u> . Approximately 10,000 gallons of mill tailings and process solution containing cyanide and heavy metals (20 mg/L cyanide) was released from the west sand plant into a storm sewer that discharges into Gold Run Creek.
1998	<u>June</u> . OEA Research Consultants conducted an assessment of the aquatic life in Whitewood Creek to evaluate the effects of the May 29, 1998 release. Aquatic biological community monitoring continued for three years.
1998	<u>October</u> . <i>Screening Ecological Risk Assessment</i> completed by EPA (ISSI, 1998).
1999	<i>Quality Assurance Work Plan</i> (ERT, 1999a) completed including data quality objectives and sampling and analysis plan to fill data gaps in support of an ecological risk assessment.
1999	Aquatic field study completed by EPA Environmental Response Team (ERT, 1999b).
2000	Terrestrial field sampling completed by EPA Environmental Response Team (ERT, 2000).
2000	USGS conducted seep water toxicity tests to evaluate fathead minnow survival (USGS, 2000).
2001	Aquatic Field Study (US EPA, 2001a) and Terrestrial Field Study Reports (US EPA, 2001b) finalized.
2000-2001	Aquatic biological community monitoring continued (Chadwick Ecological Consultants, Inc., 2001; Knudsen, 2001).

**Table 2-2**  
**Fish Species Observed in Whitewood Creek**  
**and the Belle Fourche River**

*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*

<b>Common Name</b>	<i>Genus/Species</i>	<b>Whitewood Creek</b>	<b>Belle Fourche River</b>
Brown trout	<i>Salmo trutta</i>	X	
Brook trout	<i>Salvelinus fontinalis</i>	X	
Rainbow trout	<i>Onchorhynchus mykiss</i>	X	
Channel catfish	<i>Ictalurus punctatus</i>		X
Stonecat	<i>Noturus flavus</i>	X	X
Longnose dace	<i>Rhinichthys cataractae</i>	X	X
Creek chub	<i>Semotilus atromaculatus</i>	X	X
Flathead chub	<i>Hybopsis gracilis</i>	X	X
Sand shiner	<i>Notropis stramineus</i>	X	X
Fathead minnow	<i>Pimephales promelas</i>	X	X
Common carp	<i>Cyprinus carpio</i>	X	X
Plains minnow or Western silvery	<i>Hybognathus placitus</i> or <i>H. argyritis</i>		X
Red shiner	<i>Cyprinella lutrensis</i>	X	X
River carpsucker	<i>Carpionodes carpio</i>		X
White sucker	<i>Catostomus commersoni</i>	X	X
Shorthead redhorse	<i>Maxostoma macrolepidotum</i>		X
Mountain sucker	<i>Catostomus platyrhynchus</i>	X	
Plains killifish	<i>Fundulus zebrinus</i>	X	
Black crappie	<i>Pomoxis nigromaculatus</i>		X
Green sunfish	<i>Lepomis cyanellus</i>	X	X
Largemouth bass	<i>Micropterus salmoides</i>		X
Yellow perch	<i>Perca flavescens</i>		X
Walleye	<i>Stizostedion vitreum</i>		X

Data Sources:  
 Chadwick (1997)  
 Chadwick and Associates (1990a, 1990b, 1996, 2001)  
 Knudson (2001a, 2001b)  
 ERT (2001a)

**Table 2-3**  
**Amphibian and Reptile Species Observed**  
**within the Whitewood Creek Site Area**

*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*

Common Name	Genus/Species
Tiger salamander+	<i>Ambystoma tigrinum</i>
Leopard frog	<i>Rana pipiens</i>
Plains garter snake	<i>Thamnophis radix</i>
Bull snake	<i>Pituophis melanoleucus</i>
Eastern yellow-bellied racer+	<i>Coluber constrictor</i>
Painted turtle	<i>Chrysemys picta</i>
Snapping turtle+	<i>Chelydra serpentina</i>

As reported in Knowles (1996a)

+ Observed only in 1996

**Table 2-4**  
**Avian Species Observed within the Whitewood Creek Site Area**

**Ecological Risk Assessment**  
**Whitewood Creek Site, Lead, South Dakota**

Common Name	Genus/Species	Common Name	Genus/Species
American avocet*	<i>Recurvirostra americana</i>	Vesper sparrow	<i>Poocetes gramineus</i>
American crow	<i>Corvus brachyrhynchos</i>	Warbling vireo	<i>Vireo gilvus</i>
American goldfinch	<i>Carduelis tristis</i>	Western burrowing owl	<i>Athene cunicularia</i>
American kestrel	<i>Falco sparverius</i>	Western kingbird	<i>Tyrannus verticalis</i>
American redstart	<i>Setophaga ruticilla</i>	Western meadowlark	<i>Sturnella neglecta</i>
American robin	<i>Turdus migratorius</i>	Western tanager	<i>Piranga ludoviciana</i>
American tree sparrow	<i>Spizella arborea</i>	Western wood-pewee	<i>Contopus sordidulus</i>
American wigeon	<i>Anas americana</i>	White-breasted nuthatch	<i>Sitta carolinensis</i>
American white pelican	<i>Pelecanus erythrorhynchos</i>	White-crowned sparrow	<i>Zonotrichia leucophrys</i>
Bald eagle	<i>Haliaeetus leucocephalus</i>	Wild turkey	<i>Meleagris gallopavo</i>
Bank swallow*	<i>Riparia riparia</i>	Wilson's phalarope	<i>Phalaropus tricolor</i>
Barn swallow	<i>Hirundo rustica</i>	Wilson's warbler	<i>Wilsonia pusilla</i>
Belted kingfisher	<i>Ceryle alcyon</i>	Wood duck	<i>Aix sponsa</i>
Black-billed magpie	<i>Pica pica</i>	Yellow-billed cuckoo	<i>Coccyzus americanus</i>
Black-capped chickadee	<i>Parus atricapillus</i>	Yellow-breasted chat	<i>Icteria virens</i>
Black-headed grosbeak	<i>Pheucticus melanocephalus</i>	Yellow-headed blackbird	<i>Xanthocephalus xanthocephalus</i>
Blue grosbeak*	<i>Guiraca caerulea</i>	Yellow-rumped warbler	<i>Dendroica coronata</i>
Blue jay	<i>Cyanocitta cristata</i>	Yellow warbler	<i>Dendroica petechia</i>
Blue-winged teal	<i>Anas discors</i>	Killdeer	<i>Charadrius vociferus</i>
Bobolink*	<i>Dolichonyx oryzivorus</i>	Lark bunting	<i>Calamospiza melanocorys</i>
Brewer's blackbird	<i>Euphagus cyanocephalus</i>	Lark sparrow	<i>Chondestes grammacus</i>
Brown-headed cowbird	<i>Molothrus ater</i>	Lazuli bunting	<i>Passerina amoena</i>
Brown thrasher	<i>Toxostoma rufum</i>	Least flycatcher	<i>Empidonax minimus</i>
Bufflehead	<i>Bucephala albeola</i>	Lewis' woodpecker+	<i>Melanerpes lewis</i>
Canada goose	<i>Branta canadensis</i>	Long-billed curlew*	<i>Numenius americanus</i>
Cassin's kingbird	<i>Tyrannus vociferans</i>	Lincoln's sparrow*	<i>Melospiza lincolni</i>
Cedar waxwing	<i>Bombycilla cedrorum</i>	Loggerhead shrike+	<i>Lanius ludovicianus</i>
Chipping sparrow	<i>Spizella passerina</i>	Mallard	<i>Anas platyrhynchos</i>
Clay-colored sparrow	<i>Spizella pallida</i>	Merlin	<i>Falco columbarius</i>
Cliff swallow	<i>Hirundo pyrrhonota</i>	Mourning dove	<i>Zenaida macroura</i>
Common flicker	<i>Colaptes auratus</i>	Northern goshawk	<i>Accipiter gentilis</i>
Common grackle	<i>Quiscalus quiscula</i>	Northern harrier	<i>Circus cyaneus</i>
Common merganser+	<i>Mergus merganser</i>	Northern mockingbird+	<i>Mimus polyglottos</i>
Common nighthawk	<i>Chordeiles minor</i>	Northern oriole+	<i>Icterus galbula</i>
Common snipe	<i>Gallinago gallinago</i>	Northern pintail	<i>Anas acuta</i>
Common yellowthroat	<i>Geothlypis trichas</i>	Northern rough-winged swallow	<i>Stelgidopteryx serripennis</i>
Cooper's hawk	<i>Accipiter cooperii</i>	Orchard oriole	<i>Icterus spurius</i>
Dark-eyed junco	<i>Junco hyemalis</i>	Osprey+	<i>Pandion haliaetus</i>
Dickcissel+	<i>Spiza americana</i>	Ovenbird	<i>Seiurus aurocapillus</i>
Double-crested cormorant	<i>Phalacrocorax auritus</i>	Prairie falcon	<i>Falco mexicanus</i>
Downy woodpecker+	<i>Picoides pubescens</i>	Red-breasted nuthatch*	<i>Sitta canadensis</i>
Dusky flycatcher*	<i>Empidonax oberholseri</i>	Red crossbill	<i>Loxia curvirostra</i>
Eastern bluebird+	<i>Sialia sialis</i>	Red-eyed vireo	<i>Vireo olivaceus</i>
Eastern kingbird	<i>Tyrannus tyrannus</i>	Redhead	<i>Aythya americana</i>
European starling	<i>Sturnus vulgaris</i>	Red-headed woodpecker	<i>Melanerpes erythrocephalus</i>
Ferruginous hawk+	<i>Buteo regalis</i>	Red-tailed hawk	<i>Buteo jamaicensis</i>
Field sparrow+	<i>Spizella pusilla</i>	Red-winged blackbird	<i>Agelaius phoeniceus</i>
Gadwal	<i>Anas strepera</i>	Ring-necked pheasant	<i>Phasianus colchicus</i>
Golden eagle	<i>Aquila chrysaetos</i>	Rock dove	<i>Columba livia</i>
Grasshopper sparrow	<i>Ammodramus savannarum</i>	Rough-legged hawk	<i>Buteo lagopus</i>
Gray catbird	<i>Dumetella carolinensis</i>	Ruby-crowned kinglet*	<i>Regulus calendula</i>
Gray partridge	<i>Perdix perdix</i>	Rufous-sided towhee	<i>Pipilo erythrophthalmus</i>
Great blue heron	<i>Ardea herodias</i>	Sharp-tailed grouse	<i>Tympanuchus phasianellus</i>
Great crested flycatcher	<i>Myiarchus crinitus</i>	Song sparrow*	<i>Melospiza melodia</i>
Great-horned owl	<i>Bubo virginianus</i>	Snow bunting+	<i>Plectrophenax nivalis</i>
Green-winged teal	<i>Anas crecca</i>	Sprague's pipit+	<i>Anthus spragueii</i>
Gull (unidentified)	<i>Larus spp.</i>	Spotted sandpiper	<i>Actitis macularia</i>
Hairy woodpecker	<i>Picoides villosus</i>	Swainson's hawk	<i>Buteo swainsoni</i>
Harris' sparrow+	<i>Zonotrichia querula</i>	Swainson's thrush	<i>Catharus ustulatus</i>
Horned lark	<i>Eromophila alpestris</i>	Townsend's solitaire+	<i>Myadestes townsendi</i>
House sparrow	<i>Passer domesticus</i>	Tree swallow	<i>Tachycineta bicolor</i>
House wren	<i>Troglodytes aedon</i>	Turkey vulture	<i>Cathartes aura</i>
Indigo bunting+	<i>Passerina cyanea</i>	Upland sandpiper	<i>Bartramia longicauda</i>

As reported in Knowles (1996a & 1996b)

\* Observed only in 1989 or 1990

+ Observed only in 1996

**Table 2-5**  
**Mammalian Species Observed within the Whitewood Creek Site Area**

*Ecological Risk Assessment,  
Whitewood Creek Site, Lead, South Dakota*

Common Name	Genus/Species
Deer mouse	<i>Peromyscus maniculatus</i>
White-footed mouse+	<i>Peromyscus leucopus</i>
Meadow jumping mouse+	<i>Zapus hudsonius</i>
Meadow vole+	<i>Microtus pennsylvanicus</i>
Prairie vole+	<i>Microtus ochrogaster</i>
Masked shrew+	<i>Sorex cinereus</i>
Northern pocket gopher	<i>Thomomys talpoides</i>
House mouse+	<i>Mus musculus</i>
Eastern fox squirrel	<i>Sciurus niger</i>
Red squirrel*	<i>Tamiasciurus hudsonicus</i>
13-lined ground squirrel	<i>Spermophilus tridecemlineatus</i>
Porcupine	<i>Erethizon dorsatum</i>
Muskrat	<i>Ondatra zibethicus</i>
Beaver	<i>Castor canadensis</i>
Cottontail rabbit (spp.)	<i>Sylvilagus spp.</i>
White-tailed jackrabbit	<i>Lepus townsendii</i>
Raccoon+	<i>Procyon lotor</i>
Badger	<i>Taxidea taxus</i>
Red fox	<i>Vulpes vulpes</i>
Coyote	<i>Canis latrans</i>
Mule deer	<i>Odocoileus hemionus</i>
White-tailed deer	<i>Odocoileus virginianus</i>

As reported in Knowles (1996a)

\* Observed only in 1989 or 1990

+ Observed only in 1996

**Table 2-6**  
**Threatened or Endangered Vertebrate Wildlife Species that Potentially Inhabit Site Area**

*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*

Common Name	Genus/Species	Federal Status	State Status
Piping plover	<i>Charadrius melodus</i>	T	T
Peregrine falcon	<i>Falco peregrinus</i>	E	E
Whooping crane	<i>Grus americana</i>	E	E
Bald eagle	<i>Haliaeetus leucocephalus</i>	T	E
Osprey	<i>Pandion haliaetus</i>		T
Interior least tern	<i>Sterna antillarum</i>	E	E
Mountain lion	<i>Felis concolor</i>		T
River otter	<i>Lutra canadensis</i>		T
Black-footed ferret	<i>Mustela nigripes</i>	E	E
Black bear	<i>Ursus americanus</i>		T
Swift fox	<i>Vulpes velox</i>		T
Black Hills redbelly snake	<i>Storeria occipitomaculata</i>		T

Information from Knowles (1996a)

T= Threatened

E = Endangered

**Table 3-1**  
**Summary of the Results of the SERA**

***Ecological Risk Assessment***  
***Whitewood Creek Site, Lead, South Dakota***

<b>Medium</b>	<b>Receptor of Interest (ROI)</b>	<b>Exposure Pathway</b>	<b>Constituent</b>	<b>Range of HQ Values</b>	<b>Further Evaluation (Yes/No)</b>
<b>Surface Water</b>	Aquatic Invertebrates and Fish	Direct Contact	Dissolved lead and zinc	2 to 4	Yes
			Total recoverable arsenic, copper, lead, mercury, nickel and zinc	2 to 30	Yes
	Mammals	Ingestion	Lead and arsenic	2 to 3	Yes
<b>Sediment</b>	Benthic Invertebrates	Direct Contact	Antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc	2 to 2,000	Yes
	Avian and mammalian piscivores (mink and kingfisher)	Ingestion	Arsenic	2 to 20	Yes
	Avian aquatic insectivores (swallow)	Ingestion	Arsenic, chromium and copper	2 to 30	Yes
<b>Soil</b>	Vegetation	Direct Contact	Arsenic, cadmium, copper, nickel, selenium and zinc	2 to 700	Yes
	Soil Organisms	Direct Contact	Arsenic, cadmium, chromium, copper, mercury, nickel, selenium and zinc	2 to 300	Yes
	Avian and mammalian insectivores (robin and shrew)	Ingestion	Arsenic, cadmium, chromium, and copper	2 to 200	Yes
<b>Food web</b>	Avian insectivores (robin)	Ingestion of soil organisms	Arsenic, cadmium, chromium, lead, mercury, nickel and selenium	2 to 100	Yes
	Mammalian insectivores (shrew)	Ingestion of soil organisms	Arsenic, cadmium, nickel, selenium and zinc	2 to 100	Yes
	Mammalian omnivores (mouse)	Ingestion of soil organisms	Arsenic and cadmium	2 to 6	Yes
	Mammalian herbivores (deer)	Ingestion of vegetation	Arsenic	6 to 9	Yes
	Avian aquatic insectivores (swallow)	Ingestion of benthic invertebrates	Arsenic, cadmium, chromium, copper, lead, mercury, and selenium	2 to 30	Yes

**Table 3-2**  
**Summary of Data Gaps Identified in the SERA**

***Ecological Risk Assessment***  
***Whitewood Creek Site, Lead, South Dakota***

<b>Receptor</b>	<b>Exposure Medium</b>	<b>Data Gaps</b>	<b>Potential Data Collection</b>
Benthic Invertebrates	Sediment	<ul style="list-style-type: none"> <li>Better definition of extent of sediment exposures</li> </ul>	<ul style="list-style-type: none"> <li>Additional measurements of COPC concentrations in sediments</li> </ul>
		<ul style="list-style-type: none"> <li>Bioavailability of metals in sediments</li> </ul>	<ul style="list-style-type: none"> <li>Measurements of COPCs in interstitial water of sediment at seeps</li> <li>AVS/SEM measurements</li> </ul>
		<ul style="list-style-type: none"> <li>Extent of site-specific sediment toxicity</li> </ul>	<ul style="list-style-type: none"> <li>Sediment toxicity testing</li> <li>Re-evaluation of current community data</li> <li>Samples of benthic invertebrate community metrics in comparison to reference</li> </ul>
Fish	Surface water, sediment and diet	<ul style="list-style-type: none"> <li>COPC concentrations in diet</li> <li>Bioavailability of mercury</li> <li>Extent of site-specific effects of metals exposure</li> </ul>	<ul style="list-style-type: none"> <li>Measurement of COPC concentrations in benthic invertebrates</li> <li>Tissue measurements of mercury</li> <li>Re-evaluation of current community data</li> <li>Fish community structure analyses</li> </ul>
Wildlife	Soil, sediment and diet	<ul style="list-style-type: none"> <li>Better definition of exposures and bioavailability of metals from soils, sediments and diet</li> <li>Derivation of site-specific BAFs</li> <li>Extent of site-specific effects of metals exposure</li> </ul>	<ul style="list-style-type: none"> <li>Sediment bioaccumulation tests</li> <li>Constituent concentrations in soil invertebrates</li> <li>Constituent concentrations in vegetation</li> <li>Constituent concentrations in small mammals</li> <li>Evaluation of current wildlife census data</li> <li>Census studies</li> </ul>
Vegetation and Soil Invertebrates	Soil	<ul style="list-style-type: none"> <li>Site-specific soil toxicity</li> </ul>	<ul style="list-style-type: none"> <li>Soil toxicity testing</li> </ul>

**Table 3-3**  
**Summary of COPCs Selected for Quantitative Analysis**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

Parameters	Aquatic Receptors		Wildlife Receptors			Plants & Soil Invertebrates
	Surface Water	Sediment	Surface Water	Sediment	Soil	Soil
Aluminum	X			X	X	X
Antimony				X	X	X
Arsenic		X	X	X	X	X
Barium				X	X	X
Beryllium					X	
Boron				X		X
Cadmium		X		X	X	
Chromium				X	X	X
Copper	X	X		X	X	X
Cyanide	X					
Iron						X
Lead	X	X		X	X	X
Manganese		X		X	X	X
Mercury		X		X	X	X
Molybdenum				X	X	X
Nickel		X				X
Selenium	X					
Silver	X					X
Thallium					X	X
Vanadium				X	X	X
Zinc		X	X	X	X	X
<b>Total</b>	<b>6</b>	<b>8</b>	<b>2</b>	<b>14</b>	<b>15</b>	<b>17</b>

**Table 3-4**  
**Assessment Endpoints and Associated Hypotheses and Measurement Endpoints**

*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*

Assessment Endpoint	Testable Hypothesis	Measurement Endpoint (s)
<b>Stream Function and Viability</b>  (The on-site instream habitat is not significantly degraded relative to the reference)	The concentrations of COPCs in sediment, porewater, and surface water on-site are not greater than benchmark values for toxicity to fish and benthic invertebrates.	Determine the concentrations of COPCs in sediment and compare to sediment toxicity benchmarks.  Determine the concentrations of COPCs in sediment porewater and compare to ambient water quality criteria (AWQC).  Determine the concentrations of COPCs in surface water and compare to AWQC and site-specific standards.
	The number of taxa and individuals in aquatic communities on-site are not significantly less than numbers at reference.	Compare the community data for periphyton, fish, and benthic invertebrates (number of taxa, individuals, and other metrics) to previous results and reference communities.
	The toxicity of COPCs in site sediment to benthic invertebrates is not significantly greater than reference.	Evaluate the toxicity of site sediment to the amphipod ( <i>Hyaella azteca</i> ) (growth and survival) through laboratory testing.  Evaluate the bioavailability of COPCs in sediment using both porewater and AVS/SEM measurements.
	The release of seep water is not significantly increasing the in-stream toxicity of surface water in WWC.	Determine the concentration of COPCs in water from seeps and compare to AWQC.  Evaluate the acute toxicity of seep water to the fathead minnow ( <i>Pimephales promelas</i> ) through laboratory testing.
	The concentrations of COPCs in benthic invertebrates and sediment on-site are not greater than toxicity benchmark values for ingestion by fish.	Determine the concentrations of COPCs in benthic invertebrate tissues and compare to toxicity benchmarks for fish ingestion.  Determine the concentrations of COPCs in sediment and compare to toxicity benchmarks for fish ingestion.
	The concentrations of COPCs in fish tissue on-site are not greater than toxicity benchmark values.	Determine the concentrations of COPCs in fish tissue and compare to toxicity benchmarks for fish tissue.
<b>Riparian Floodplain Function and Viability</b>  (The on-site riparian habitat is not significantly degraded relative to the reference)	The concentration of COPCs in on-site riparian floodplain soils and seep water is not greater than benchmark values.	Determine the concentrations of COPCs in soil and compare to toxicity benchmarks for plants and soil invertebrates.  Determine the concentrations of COPCs in interstitial seep water and compare to toxicity benchmarks for plants.
	The toxicity of riparian floodplain soils is not significantly greater than reference.	Evaluate the toxicity of COPCs from soil through solid-phase testing using earthworms.  Evaluate the toxicity of COPCs in soil through laboratory toxicity testing using plants.
	The number of vascular plant taxa on-site are not significantly less than the numbers at reference.	Compare the vascular plant community-types present on-site to reference.
	Soil function on site is not different than that at reference locations.	Compare the soil function parameters on-site to that at reference.

**Table 3-4**  
**Assessment Endpoints and Associated Hypotheses and Measurement Endpoints**

*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*

Assessment Endpoint	Testable Hypothesis	Measurement Endpoint (s)
<b>Viability of Insectivorous Wildlife</b>	The concentration of COPCs in food items of surrogate insectivorous wildlife species on-site is not significantly greater than reference.	Determine the concentrations of COPCs in soil, surface water, and sediment collected on-site and compare to those detected at the reference locations.  Determine the concentrations of COPCs in selected food items (earthworms and grasshoppers) and compare on-site concentrations to reference.
	The dietary exposure of surrogate insectivorous wildlife species to COPCs on-site is not greater than toxicity reference values.	Through food chain models for the cliff swallow ( <i>Petrochelidon pyrrhonota</i> ), American robin ( <i>Turdus migratorius</i> ), and the masked shrew ( <i>Sorex cinereus</i> ), estimate the daily dose of each COPC and compare to respective toxicity reference value (dose associated with no adverse effect). Compare results for on-site to reference.
	The body burden of COPCs in selected species on-site is not greater than reference.	Determine body burdens of COPCs in the masked shrew ( <i>Sorex cinereus</i> ) and/or other small mammals on-site and compare to reference.
	The body burden of COPCs in selected species on-site is not greater than benchmark values.	Determine body burdens of COPCs in the masked shrew ( <i>Sorex cinereus</i> ) and/or other small mammals on-site and compare to toxicity benchmarks for tissue burdens.
	The histopathology of organ tissues in selected species on-site is not significantly different from reference.	Determine the weights of liver, kidney and spleen in the masked shrew ( <i>Sorex cinereus</i> ) and/or other small mammals on-site and compare to reference.  Examine the liver, kidney and spleen in the masked shrew ( <i>Sorex cinereus</i> ) and/or other small mammals on-site for abnormalities and compare to reference.
<b>Viability of Herbivorous/ Omnivorous Wildlife</b>	The concentration of COPCs in food items of surrogate herbivorous and omnivorous wildlife species on-site is not significantly greater than reference or site-specific background.	Determine the concentrations of COPCs in soil, surface water, and sediment collected on-site and compare to those detected at the reference locations and background.  Determine the concentrations of COPCs in selected food items (plants) and compare on-site concentrations to reference.  Estimate concentrations of COPCs in food items and compare on-site concentrations to reference.
	The dietary exposure of surrogate herbivorous and omnivorous wildlife species to COPCs on-site is not greater than toxicity reference values.	Through food chain models for the meadow vole ( <i>Microtis pennsylvanicus</i> ) and deer mouse ( <i>Peromyscus maniculatus</i> ), estimate the daily dose of each COPC and compare to respective toxicity reference value (dose associated with no adverse effect). Compare results for on-site to reference.
	The body burden of COPCs in selected species on-site is not greater than reference.	Determine body burdens of COPCs in small mammals on-site and compare to reference.
	The body burden of COPCs in selected species on-site is not greater than benchmark values.	Determine body burdens of COPCs in small mammals and compare to toxicity benchmarks for tissue burdens.

**Table 3-4**  
**Assessment Endpoints and Associated Hypotheses and Measurement Endpoints**

*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*

Assessment Endpoint	Testable Hypothesis	Measurement Endpoint (s)
<b>Viability of Herbivorous/Omnivorous Wildlife (cont.)</b>	The histopathology of organ tissues in selected species on-site is not significantly different from reference.	Determine the weights of liver, kidney and spleen in the the meadow vole ( <i>Microtis pennsylvanicus</i> ) and deer mouse and/or other small mammals on-site and compare to reference.  Examine the liver, kidney and spleen in the the meadow vole ( <i>Microtis pennsylvanicus</i> ) and deer mouse ( <i>Peromyscus maniculatus</i> ) and/or other small mammals on-site for abnormalities and compare to reference.
<b>Viability of Carnivorous Wildlife</b>	The concentration of COPCs in food items of surrogate carnivorous species on-site is not significantly greater than reference or site-specific background.	Determine the concentrations of COPCs in soil, surface water, and sediment collected on-site and compare to those at reference.  Determine the concentrations of COPCs in selected food items (small mammals) and compare on-site concentrations to reference.  Estimate concentrations of COPCs in food items and compare on-site concentrations to reference and background.
	The dietary exposure of surrogate carnivorous species to COPCs on-site is not greater than toxicity reference values.	Through food chain models for the American kestrel ( <i>Falco sparverius</i> ), great horned owl ( <i>Bubo virginianus</i> ), and red fox ( <i>Vulpes vulpes</i> ), estimate the daily dose of each COPC and compare to respective toxicity reference value (dose associated with no adverse effect). Compare results for on-site to reference.
<b>Viability of Aquatic Insectivorous Wildlife</b>	The concentration of COPCs in food items of surrogate aquatic insectivorous wildlife species on-site is not significantly greater than reference or site-specific background.	Determine the concentrations of COPCs in soil, surface water, and sediment collected on-site and compare to those detected at the reference locations.  Determine the concentrations of COPCs in selected food items (aquatic invertebrates) and compare on-site concentrations to reference.  Estimate concentrations of COPCs in food items and compare on-site concentrations to reference.
	The dietary exposure of surrogate aquatic insectivorous wildlife species to COPCs on-site is not greater than toxicity reference values.	Through food chain models for the American dipper ( <i>Cinclus mexicanus</i> ), estimate the daily dose of each COPC and compare to respective toxicity reference value (dose associated with no adverse effect). Compare results for on-site to reference.
<b>Viability of Piscivorous Wildlife</b>	The concentration of COPCs in food items of surrogate piscivorous species on-site is not significantly greater than reference or site-specific background.	Determine the concentrations of COPCs in surface water and sediment collected on-site and compare to those at reference.  Determine the concentrations of COPCs in selected food items (fish) and compare on-site concentrations to reference.  Estimate concentrations of COPCs in food items and compare on-site concentrations to reference.

**Table 3-4**  
**Assessment Endpoints and Associated Hypotheses and Measurement Endpoints**

*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*

Assessment Endpoint	Testable Hypothesis	Measurement Endpoint (s)
<b>Viability of Piscivorous Wildlife (cont.)</b>	The dietary exposure of surrogate piscivorous species to COPCs on-site is not greater than toxicity reference values.	Through a food chain model for the belted kingfisher ( <i>Megaceryle alcyon</i> ) and the mink ( <i>Mustela vison</i> ), estimate the daily dose of each COPC and compare to respective toxicity reference value (dose associated with no adverse effect). Compare results for on-site to reference.
<b>Viability of Amphibian Community</b>	The concentrations of COPCs in surface water and seeps are not greater than benchmarks.	Determine the concentration of COPCs in surface water and seeps and compare to toxicity benchmarks.
	The toxicity of COPCs in on-site sediment is not significantly greater than at the reference.	Inference of sediment toxicity observed in macroinvertebrate exposures to amphibians.

**Table 4-1**  
**Summary of Data Collected in the March 1999 ERT Aquatic Field Investigation**

*Ecological Risk Assessment for the Whitewood Creek Site, South Dakota*

Station	Surface	Sediment	SEM/AVS	Pore Water	Groundwater	Benthic	Fish	Toxicity	Community
WWC-R-01 M	X	X		X		X		H	A
WWC-02	X	X		X		X		H	A
WWC-03	X	X		X		X		H	A
WWC-04	X	X		X		X		H	A
WWC-05	X	X		X		X		H	A
WWC-06	X	X	X	X	X (seep)	X	X	H	A
WWC-07	X	X		X				H	A
WWC-08	X	X	X	X	X (seep)	X	X	H	A
WWC-09	X	X	X	X	X (seep)	X		H	A
BFR-R-10	X	X	X	X	X (gw)		X	H	A
BFR-11	X	X	X	X	X (gw)	X	X	H	A
SPC-R-12	X	X	X	X	X (gw)	X	X	H	A

H = *Hyalella azteca*

A = Aquatic Habitat

**Table 4-2**  
**Summary of Data Collected in the ERT Terrestrial Field Investigation**  
*Ecological Risk Assessment for the Whitewood Creek Site, South Dakota*

Station	Soils - Flood Plain		Plants	Small Mammals	Terrestrial Invertebrates	Toxicity Tests	Community Evaluations
	Mar 1999	Aug 1999					
WWC-R-01 M	X					E, T	
WWC-R-01 A		X	X	X	X	R	P, S
WWC-05	X	X	X	X	X	R, T	P, S
WWC-06	X	X	X	X	X	E, R, T	P, S
WWC-07	X					E, T	
WWC-08	X	X	X	X	X	E, R, T	P, S
WWC-09	X					E, T	
BFR-R-10	X					E, T	
SPC-R-12	X	X	X	X	X	E, R, T	P, S

E = Earthworm (*Eisenia foetida*)  
R = Rye Grass (*Lolium perenne*)  
T = Turnip Seed (*Brassica rapa*)

P = Plant  
S = Soil

**Table 5-1 Summary of Data Used in the Risk Assessment**

<b>Data Type</b>	<b>Medium</b>	<b>Analyses</b>	<b>Location</b>	<b>Source</b>
Abiotic Concentrations	Surface Water	Total/Dissolved TAL Inorganics Total Cyanide Water Quality Parameters	2 gaging stations on Whitewood Creek	USGS (downloaded from STORET and manually entered)
		Total/Dissolved TAL Inorganics Total/WAD Cyanide Water Quality Parameters	6 water quality monitoring stations on Whitewood Creek	SDDENR (downloaded from STORET and manually entered)
		Total/Dissolved TAL Inorganics Total Cyanide Water Quality Parameters	9 stations on Whitewood Creek 2 stations on Belle Fourche River 1 station on Spearfish Creek	ERT Aquatic Field Investigation (USEPA, 2001a)
	Sediment	TAL Inorganics Total Cyanide SEM/AVS	9 stations on Whitewood Creek 2 stations on Belle Fourche River 1 station on Spearfish Creek	ERT Aquatic Field Investigation (USEPA, 2001a)
	Seep Water	TAL Inorganics Water Quality Parameters	5 seeps along Whitewood Creek	Fathead Minnow Toxicity Study (USGS, 2000)
		Total TAL Inorganics, molybdenum, boron Water Quality Parameters	4 seeps along Whitewood Creek	ERT Aquatic Field Investigation (USEPA, 2001a)
	Soil	TAL Inorganics Total Cyanide	6 stations on Whitewood Creek 1 station on Belle Fourche River 1 station on Spearfish Creek	ERT Terrestrial Field Investigation (USEPA, 2001b)
Biotic Tissue Concentrations	BMI	Total TAL Inorganics Percent Moisture (depurated and non-depurated)	9 stations on Whitewood Creek 2 stations on Belle Fourche River 1 station on Spearfish Creek	ERT Aquatic Field Investigation (USEPA, 2001a)
	Fish	Arsenic, lead, mercury, selenium, and zinc (whole body samples)	4 stations on Whitewood Creek 1 station on Belle Fourche River	Chadwick Ecological Consultants, Inc. (1996)
		Total TAL Inorganics Percent Moisture (whole body samples)	2 stations on Whitewood Creek 2 stations on Belle Fourche River 1 station on Spearfish Creek	ERT Aquatic Field Investigation (USEPA, 2001a)

Data Type	Medium	Analyses	Location	Source
Biotic Tissue Concentrations (cont.)	Plant	Total TAL Inorganics Percent Moisture (washed and unwashed grasses and clover samples)	4 stations on Whitewood Creek 1 station on Spearfish Creek	ERT Terrestrial Field Investigation (USEPA, 2001b)
	Grasshopper	Total TAL Inorganics Percent Lipid Content	4 stations on Whitewood Creek 1 station on Spearfish Creek	ERT Terrestrial Field Investigation (USEPA, 2001b)
	Earthworm	Total TAL Inorganics (14 and 28-day bioaccumulation)	6 stations on Whitewood Creek 1 station on Belle Fourche River 1 station on Spearfish Creek	Soil Toxicity Study in ERT Terrestrial Field Investigation (USEPA, 2001b)
	Small Mammal	Total TAL Inorganics Percent Lipid Content (whole body, kidney, liver, spleen samples)	4 stations on Whitewood Creek 1 station on Spearfish Creek	ERT Terrestrial Field Investigation (USEPA, 2001b)
	Birds	Total Arsenic (eggs, carcasses, liver, diet samples)	2 stations on Whitewood Creek	Custer (1997)
Site-Specific Toxicity Tests	BMI	10-day chronic toxicity to the amphipod ( <i>Hyalella azteca</i> )	9 stations on Whitewood Creek 2 stations on Belle Fourche River 1 station on Spearfish Creek	ERT Aquatic Field Investigation (USEPA, 2001a)
	Fish	Acute toxicity to the larval fathead minnow ( <i>Pimephales promelas</i> )	5 seeps along Whitewood Creek, plus upstream and downstream samples at each seep	Fathead Minnow Toxicity Study (USGS, 2000)
	Plant	Toxicity to the turnip seed ( <i>Brassica rapa</i> )	4 stations on Whitewood Creek 1 station on Spearfish Creek	Soil Toxicity Study in ERT Terrestrial Field Investigation (USEPA, 2001b)
		28-day toxicity to ryegrass ( <i>Lolium perenne</i> )	6 stations on Whitewood Creek 1 station on Belle Fourche River 1 station on Spearfish Creek	Soil Toxicity Study in ERT Terrestrial Field Investigation (USEPA, 2001b)
	Earthworm	28-day toxicity to earthworms ( <i>Eisenia foetida</i> )	6 stations on Whitewood Creek 1 station on Belle Fourche River 1 station on Spearfish Creek	Soil Toxicity Study in ERT Terrestrial Field Investigation (USEPA, 2001b)

<b>Data Type</b>	<b>Medium</b>	<b>Analyses</b>	<b>Location</b>	<b>Source</b>
Community Surveys	Aquatic community (fish, BMI, periphyton)	Density and diversity of aquatic species	Multiple stations on Whitewood Creek, along with one or more reference locations	Chadwick (1990, 1997, 2001) Knudson (2000, 2001a, 2001b) USEPA (2001a)
	Plants	Quantitative assessment of grassland, woodland/forest, and streamside vegetation	Whitewood Creek (from Interstate 90 to the confluence with the Belle Fourche River)	Harner and Associates (1991)
		Qualitative survey of the riparian vegetative community	4 stations on Whitewood Creek 1 station on Spearfish Creek	ERT Terrestrial Field Investigation (USEPA, 2001b)
	Soil Microbes	Ecological integrity parameters of the soil ecosystem	4 stations on Whitewood Creek 1 station on Spearfish Creek	ERT Terrestrial Field Investigation (USEPA, 2001b)
	Birds & Mammals	Qualitative surveys of the birds residing near the site	Whitewood Creek	Harner and Associates (1990a,b) Knowles (1996a,b)

**Table 6-1**  
**Ambient Water Quality Criteria (AWQC) Values and Parameters**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

**Basic Equation for Hardness-Dependant COPCs:**

$$\text{AWQC (Dissolved)} = \exp[a * \ln(\text{Hardness}) + b] * [m - n * (\ln(\text{Hardness}))]$$

Analyte	Acute				Chronic				AWQC Hardness Limits (mg/L as CaCO3)				AWQC Total (ug/L) at Hardness = 200 mg/L		AWQC Dissolved (ug/L) at Hardness = 200 mg/L	
									Lower		Upper					
	a	b	m	n	a	b	m	n	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Aluminum	Not Hardness Dependant		1.0	0	Not Hardness Dependant		1.0	0	Not Hardness Dependant				750	87	750	87
Copper	0.9422	-1.700	0.960	0	0.8545	-1.702	0.960	0	10	20	400	210	26.9	16.87	25.8	16.19
Cyanide*	Not Hardness Dependant		1.0	0	Not Hardness Dependant		1.0	0	Not Hardness Dependant				22	5.2	22	5.2
Lead	1.273	-1.460	1.462	0.1457	1.273	-4.705	1.462	0.1457	20	30	360	150	197.3	5.33	136.1	3.90
Selenium	Not Hardness Dependant		0.922	0	Not Hardness Dependant		0.922	0	Not Hardness Dependant				19.3	5.0	17.8	4.6
Silver	1.72	-6.52	0.850	0	na	na	na	na	10	na	400	na	13.4	na	11.4	na

na = Not Available

\* Cyanide AWQC is based on free cyanide

**SURFACE WATER AWQC NOTES:**

Source: EPA-822-Z-99-001

Total Selenium CMC Source: EPA-820-B-96-001

For table presentation, hardness-dependent values are calculated using a hardness of 200 mg/L.

If measured station hardness is outside of the specified hardness limits, the applicable hardness limit was used to calculate the AWQC.

**Table 6-2**  
**Summary of Sediment Data Used in the ERA**

*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*

Analyte	Sediment Concentration (mg/kg)											
	WWC-R-01 M	WWC-02	WWC-03	WWC-04	WWC-05	WWC-06	WWC-07	WWC-08	WWC-09	BFR-R-10	BFR-11	SPC-R-12
Aluminum	2,430	7,980	9,050	6,840	6,030	6,210	5,410	5,200	7,860	5,640	6,990	3,140
Antimony	0.96 U	3.2 J	1.5 J	2 J	1.7 J	2.4 J	0.96 U	0.93 U	1 U	0.98 U	1.1 U	0.97 U
Arsenic	19.5	235	484	608	1,150	1,230	607	768	546	13.5	1,400	13.5
Barium	73.8	167	440	201	175	133	151	124	181	254	183	133
Beryllium	0.63	0.91	0.94	0.83	0.9	0.96	0.87	0.75	0.87	0.91	0.99	0.51
Boron	2.9	4.3	41.7	7.7	8.6	10	8.3	6.4	13.5	14.3	12.8	6.8
Cadmium	0.2	1.1	1.8	1.4	1.1	1.0	0.68	0.93	1.3	1.9	1.3	0.37
Calcium	26,400	21,000	25,700	22,500	41,200	21,700	22,900	19,000	29,500	41,800	22,300	163,000
Chromium	4.1	19	30.1	17.2	12.1	13.7	9.7	10.1	14	9.4	11.6	6.3
Cobalt	2.9	12.1	15.2	12.1	12.1	11.2	8.7	8.6	9.8	8.4	9.5	2.1
Copper	8.0	43	93	109	55.2	48.9	33	34.3	36.6	20.6	31.1	6.8
Cyanide	0.61 U	0.8 U	2.6	1.2	1.1 U	0.7 U	0.6 U	0.63 U	0.64 U	0.71 U	0.93 U	0.73 U
Iron	7,560	40,200	59,500	42,400	45,800	51,900	34,900	41,200	39,300	21,700	43,800	5,320
Lead	10.9	14.8	245	44.8	27	19.5	14.5	12.8	16.1	11.8	20.3	13.8
Magnesium	4,150	7,110	6,880	7,020	7,300	5,720	4,590	5,010	7,140	3,400	4,980	16,100
Manganese	228	1,130	1,100	902	862	772	610	820	713	623	844	194
Mercury	0.08	0.19	0.34	0.27	0.65	0.36	0.26	0.31	0.27	0.08 U	0.17	0.08 U
Molybdenum	0.51	1.7	3.6	2.2	2.2	3.0	1.9	1.9	1.9	4.6	2.2	0.16 U
Nickel	4.0	32.6	38.6	31.6	22.1	25.9	20.2	18	24.3	25.5	21.8	4.6
Potassium	557	2,200	2,830	2,210	1,700	1,720	1,570	1,400	2,110	1,360	1,580	951
Selenium	0.85	1.1	1.6	0.71	1.9	2.4	1.6	1.4	2.2	2.8	2.3	0.7
Silver	0.16 U	0.19 U	0.52	0.25	0.38	0.34	0.16 U	0.16 U	0.17 U	0.16 U	0.18 U	0.16 U
Sodium	43.8	108	445	271	206	112	57.5	116	203	273	228	185
Thallium	0.96 U	1.1 U	0.95 U	0.87 U	1.4 U	1 U	0.96 U	0.93 U	1 U	0.98 U	1.1 U	0.97 U
Vanadium	8.4	28.1	42.7	31.7	27.6	29.7	21.8	22.7	38.1	46.2	39.7	10.6
Zinc	20.7	139	216	133	101	125	72.5	61.3	94.3	78.1	76.8	25.2

U = Not detected

J = Estimated

**Table 6-3**  
**Reliability of Individual Consensus-Based Sediment Quality Guidelines**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

<b>COPC</b>	<b>% of Samples Correctly Predicted to Be Non-Toxic based on TEC</b>	<b>TEC Reliable?</b>	<b>% of Samples Correctly Predicted to Be Toxic based on PEC</b>	<b>PEC Reliable?</b>
Arsenic	74.1%	No	76.9%	Yes
Cadmium	80.4	Yes	93.7	Yes
Chromium	72.0	No	91.7	Yes
Copper	82.3	Yes	91.7	Yes
Lead	81.6	Yes	89.6	Yes
Mercury	34.3	No	100	Yes
Nickel	72.3	No	90.6	Yes
Zinc	81.6	Yes	90.0	Yes

Source: MacDonald et al. (2000)

**Table 6-4**  
**Sediment Toxicity Benchmarks for Benthic Invertebrates**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

Analyte	Low Sediment TRV (mg/kg)	TRV Type	High Sediment TRV (mg/kg)	TRV Type	Source
<b>Arsenic</b>	9.79	Consensus-Based TEC	33.0	Consensus-Based PEC	a
<b>Cadmium</b>	0.99	Consensus-Based TEC	5.0	Consensus-Based PEC	a
<b>Copper</b>	31.6	Consensus-Based TEC	149	Consensus-Based PEC	a
<b>Lead</b>	35.8	Consensus-Based TEC	128	Consensus-Based PEC	a
<b>Manganese</b>	631	NERM 28 day <i>H. azteca</i>	4460	NEC 28 day <i>H. azteca</i>	b
<b>Mercury</b>	0.18	Consensus-Based TEC	1.06	Consensus-Based PEC	a
<b>Nickel</b>	22.7	Consensus-Based TEC	48.6	Consensus-Based PEC	a
<b>Zinc</b>	121	Consensus-Based TEC	459	Consensus-Based PEC	a

NERM No Effect Range Median

NEC No Effect Concentration

Sources:

a MacDonald et al. (2000)

b Ingersoll et al. (1996)

**Table 6-5**  
**Results of the Analysis for SEM/AVS in Sediments**

*Ecological Risk Assessment*  
*Whitewood Creek Site, South Dakota*

Station	Analyte	Total Conc (mg/kg)	SEM (umol/g)	AVS (umol/g)	Ratio SEM/AVS	SEM - AVS (umol/g)
WWC-06	Cadmium	0.5	0.003	2.20	0.34	-1.45
	Copper	0.5	0.21			
	Lead	1	0.12			
	Mercury	0.05	0.0005			
	Nickel	1.5	0.08			
	Zinc	5.5	0.35			
	<b>Total</b>		<b>0.75</b>			
WWC-08	Cadmium	0.5	0.001	0.01	33.40	0.24
	Copper	0.5	0.06			
	Lead	1	0.05			
	Mercury	0.05	0.0005			
	Nickel	1.5	0.04			
	Zinc	5.5	0.10			
	<b>Total</b>		<b>0.25</b>			
WWC-09	Cadmium	1.5	0.003	0.01	121.00	0.90
	Copper	3	0.22			
	Lead	1	0.05			
	Mercury	0.05	0.0005			
	Nickel	10	0.21			
	Zinc	7	0.43			
	<b>Total</b>		<b>0.91</b>			
BFR-R-10 (Reference)	Cadmium	0.5	0.012	2.46	0.40	-1.47
	Copper	0.5	0.13			
	Lead	1	0.03			
	Mercury	0.05	0.0005			
	Nickel	3.5	0.18			
	Zinc	5.5	0.63			
	<b>Total</b>		<b>0.99</b>			
BFR-11	Cadmium	0.50	0.002	0.01	96.27	0.71
	Copper	0.5	0.17			
	Lead	1	0.11			
	Mercury	0.05	0.0005			
	Nickel	3.3	0.12			
	Zinc	5.5	0.32			
	<b>Total</b>		<b>0.72</b>			
SPC-R-12 (Spearfish Creek Reference)	Cadmium	0.50	0.002	11.13	0.03	-10.84
	Copper	0.5	0.02			
	Lead	57.2	0.11			
	Mercury	0.05	0.0005			
	Nickel	1.5	0.02			
	Zinc	5.5	0.15			
	<b>Total</b>		<b>0.29</b>			

Non-detects (U) were evaluated at 1/2 the method detection limit (MDL).

**Table 6-6**  
**Fish Hazard Quotients (HQs) for the Ingestion of Benthic Invertebrates**

*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*

Monitoring Station	Analyte	Non-Depurated Benthic Tissue Concentrations (mg/kg dw)	Fish Oral TRV (mg/kg dw)		Hazard Quotients	
		Mean	NOAEL	LOAEL	NOAEL	LOAEL
US EPA (2001a) - Aquatic BFR-11	Arsenic	8.7	63.00	137.00	1E-01	6E-02
	Cadmium	0.09	55.00	165.00	2E-03	5E-04
	Copper	18	340.00	660.00	5E-02	3E-02
	Lead	0.84	170.00	510.00	5E-03	2E-03
	Zinc	102	1500.00	4500.00	7E-02	2E-02
US EPA (2001a) - Aquatic SPC-R-12	Arsenic	3.1	63.00	137.00	5E-02	2E-02
	Cadmium	0.03	55.00	165.00	5E-04	2E-04
	Copper	9.4	340.00	660.00	3E-02	1E-02
	Lead	1.4	170.00	510.00	8E-03	3E-03
	Zinc	108	1500.00	4500.00	7E-02	2E-02
US EPA (2001a) - Aquatic WWC-02	Arsenic	358	63.00	137.00	<b>6E+00</b>	<b>3E+00</b>
	Cadmium	0.72	55.00	165.00	1E-02	4E-03
	Copper	19	340.00	660.00	6E-02	3E-02
	Lead	1.4	170.00	510.00	8E-03	3E-03
	Zinc	322	1500.00	4500.00	2E-01	7E-02
US EPA (2001a) - Aquatic WWC-03	Arsenic	33	63.00	137.00	5E-01	2E-01
	Cadmium	0.09	55.00	165.00	2E-03	5E-04
	Copper	37	340.00	660.00	1E-01	6E-02
	Lead	1.1	170.00	510.00	7E-03	2E-03
	Zinc	124	1500.00	4500.00	8E-02	3E-02
US EPA (2001a) - Aquatic WWC-04	Arsenic	41	63.00	137.00	7E-01	3E-01
	Cadmium	0.19	55.00	165.00	3E-03	1E-03
	Copper	26	340.00	660.00	8E-02	4E-02
	Lead	2.8	170.00	510.00	2E-02	5E-03
	Zinc	164	1500.00	4500.00	1E-01	4E-02
US EPA (2001a) - Aquatic WWC-05	Arsenic	122	63.00	137.00	<b>2E+00</b>	9E-01
	Cadmium	0.09	55.00	165.00	2E-03	5E-04
	Copper	24	340.00	660.00	7E-02	4E-02
	Lead	1.8	170.00	510.00	1E-02	4E-03
	Zinc	133	1500.00	4500.00	9E-02	3E-02
US EPA (2001a) - Aquatic WWC-06	Arsenic	65	63.00	137.00	1E+00	5E-01
	Cadmium	0.08	55.00	165.00	1E-03	5E-04
	Copper	21	340.00	660.00	6E-02	3E-02
	Lead	1.2	170.00	510.00	7E-03	2E-03
	Zinc	120	1500.00	4500.00	8E-02	3E-02
US EPA (2001a) - Aquatic WWC-08	Arsenic	110	63.00	137.00	<b>2E+00</b>	8E-01
	Cadmium	0.13	55.00	165.00	2E-03	8E-04
	Copper	22	340.00	660.00	7E-02	3E-02
	Lead	1.3	170.00	510.00	8E-03	3E-03
	Zinc	118	1500.00	4500.00	8E-02	3E-02

**Table 6-6**  
**Fish Hazard Quotients (HQs) for the Ingestion of Benthic Invertebrates**

*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*

Monitoring Station	Analyte	Non-Depurated Benthic Tissue Concentrations (mg/kg dw)	Fish Oral TRV (mg/kg dw)		Hazard Quotients	
		Mean	NOAEL	LOAEL	NOAEL	LOAEL
US EPA (2001a) - Aquatic WWC-09	Arsenic	52	63.00	137.00	8E-01	4E-01
	Cadmium	0.10	55.00	165.00	2E-03	6E-04
	Copper	20	340.00	660.00	6E-02	3E-02
	Lead	1.2	170.00	510.00	7E-03	2E-03
	Zinc	117	1500.00	4500.00	8E-02	3E-02
US EPA (2001a) - Aquatic WWC-R-01	Arsenic	6.7	63.00	137.00	1E-01	5E-02
	Cadmium	0.21	55.00	165.00	4E-03	1E-03
	Copper	15	340.00	660.00	4E-02	2E-02
	Lead	0.87	170.00	510.00	5E-03	2E-03
	Zinc	235	1500.00	4500.00	2E-01	5E-02

NA = Not Available

NC = Not Calculated

Non-detects were evaluated at 1/2 of the detection limit.

Hazard Quotients (HQs) greater than 1E+00 are in **boldface type**.

**Table 6-7**  
**Fish Hazard Quotients (HQs) for the Incidental Ingestion of Sediments**

*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*

Monitoring Station	Analyte	Sediment Concentrations (mg/kg)	Fish Sediment Ingestion TRV (mg/kg dw)		Hazard Quotients	
		Mean	NOAEL	LOAEL	NOAEL	LOAEL
EPA (2001a) - Aquatic BFR-11	Arsenic	1,400	6,300	13,700	2E-01	1E-01
	Cadmium	1.3	5,500	16,500	2E-04	8E-05
	Copper	31	34,000	66,000	9E-04	5E-04
	Lead	20	17,000	51,000	1E-03	4E-04
	Zinc	77	150,000	450,000	5E-04	2E-04
EPA (2001a) - Aquatic BFR-R-10	Arsenic	14	6,300	13,700	2E-03	1E-03
	Cadmium	1.9	5,500	16,500	3E-04	1E-04
	Copper	21	34,000	66,000	6E-04	3E-04
	Lead	12	17,000	51,000	7E-04	2E-04
	Zinc	78	150,000	450,000	5E-04	2E-04
EPA (2001a) - Aquatic SPC-R-12	Arsenic	14	6,300	13,700	2E-03	1E-03
	Cadmium	0.37	5,500	16,500	7E-05	2E-05
	Copper	6.8	34,000	66,000	2E-04	1E-04
	Lead	14	17,000	51,000	8E-04	3E-04
	Zinc	25	150,000	450,000	2E-04	6E-05
EPA (2001a) - Aquatic WWC-02	Arsenic	235	6,300	13,700	4E-02	2E-02
	Cadmium	1.1	5,500	16,500	2E-04	7E-05
	Copper	43	34,000	66,000	1E-03	7E-04
	Lead	15	17,000	51,000	9E-04	3E-04
	Zinc	139	150,000	450,000	9E-04	3E-04
EPA (2001a) - Aquatic WWC-03	Arsenic	484	6,300	13,700	8E-02	4E-02
	Cadmium	1.8	5,500	16,500	3E-04	1E-04
	Copper	93	34,000	66,000	3E-03	1E-03
	Lead	245	17,000	51,000	1E-02	5E-03
	Zinc	216	150,000	450,000	1E-03	5E-04
EPA (2001a) - Aquatic WWC-04	Arsenic	608	6,300	13,700	1E-01	4E-02
	Cadmium	1.4	5,500	16,500	3E-04	8E-05
	Copper	109	34,000	66,000	3E-03	2E-03
	Lead	45	17,000	51,000	3E-03	9E-04
	Zinc	133	150,000	450,000	9E-04	3E-04
EPA (2001a) - Aquatic WWC-05	Arsenic	1,150	6,300	13,700	2E-01	8E-02
	Cadmium	1.1	5,500	16,500	2E-04	7E-05
	Copper	55	34,000	66,000	2E-03	8E-04
	Lead	27	17,000	51,000	2E-03	5E-04
	Zinc	101	150,000	450,000	7E-04	2E-04
EPA (2001a) - Aquatic WWC-06	Arsenic	1,230	6,300	13,700	2E-01	9E-02
	Cadmium	1.0	5,500	16,500	2E-04	6E-05
	Copper	49	34,000	66,000	1E-03	7E-04
	Lead	20	17,000	51,000	1E-03	4E-04
	Zinc	125	150,000	450,000	8E-04	3E-04
EPA (2001a) - Aquatic WWC-07	Arsenic	607	6,300	13,700	1E-01	4E-02
	Cadmium	0.68	5,500	16,500	1E-04	4E-05
	Copper	33	34,000	66,000	1E-03	5E-04
	Lead	15	17,000	51,000	9E-04	3E-04
	Zinc	73	150,000	450,000	5E-04	2E-04

**Table 6-7**  
**Fish Hazard Quotients (HQs) for the Incidental Ingestion of Sediments**

*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*

Monitoring Station	Analyte	Sediment Concentrations (mg/kg)	Fish Sediment Ingestion TRV (mg/kg dw)		Hazard Quotients	
		Mean	NOAEL	LOAEL	NOAEL	LOAEL
<b>EPA (2001a) - Aquatic WWC-08</b>	Arsenic	789	6,300	13,700	1E-01	6E-02
	Cadmium	1.0	5,500	16,500	2E-04	6E-05
	Copper	35	34,000	66,000	1E-03	5E-04
	Lead	13	17,000	51,000	8E-04	3E-04
	Zinc	64	150,000	450,000	4E-04	1E-04
<b>EPA (2001a) - Aquatic WWC-09</b>	Arsenic	565	6,300	13,700	9E-02	4E-02
	Cadmium	1.3	5,500	16,500	2E-04	8E-05
	Copper	36	34,000	66,000	1E-03	6E-04
	Lead	17	17,000	51,000	1E-03	3E-04
	Zinc	94	150,000	450,000	6E-04	2E-04
<b>EPA (2001a) - Aquatic WWC-R-01</b>	Arsenic	20	6,300	13,700	3E-03	1E-03
	Cadmium	0.20	5,500	16,500	4E-05	1E-05
	Copper	8.0	34,000	66,000	2E-04	1E-04
	Lead	11	17,000	51,000	6E-04	2E-04
	Zinc	21	150,000	450,000	1E-04	5E-05

NA = Not Available

NC = Not Calculated

Non-detects were evaluated at 1/2 of the detection limit.

Hazard Quotients (HQs) greater than 1E+00 are in **boldface type**.

**Table 6-8**  
**Summary of MATCs for Fish Tissue**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

Fish Species	Fish Maximum Allowable Tissue Concentration (MATC) (mg/kg ww)					
	Arsenic	Cadmium	Copper	Lead	Mercury	Zinc
Rainbow Trout	2.6	0.54	na	na	0.02	na
Brook Trout	na	0.13	na	0.34	na	4.5
Dace	na	0.69	na	na	na	na
Carp	na	na	3.7	na	na	na
Channel Catfish	na	na	na	na	0.17	na
Fathead Minnow	na	na	na	na	0.8	na
Largemouth Bass	na	na	na	na	na	na
<i>minimum</i>	<i>2.6</i>	<i>0.13</i>	<i>3.7</i>	<i>0.34</i>	<i>0.02</i>	<i>4.5</i>

The MATC is the highest no effect concentration which is below the lowest concentrations that caused an effect.

If an effect was observed for all tissue concentrations or if the LOAEL is lower than the NOAELs, the MATC is ½ the lowest concentration.

**Table 6-9**  
**Fish Hazard Quotients Based on Tissue Burdens**  
*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

Study	Location	COPC	MATC (mg/kg ww)	Tissue Concentration (mg/kg ww)			HQ Based on Tissue Level		
Chadwick et al. (1997)	WWC1	<i>Sample Type</i>		<i>Forage</i>	<i>Game</i>	<i>Rough</i>	<i>Forage</i>	<i>Game</i>	<i>Rough</i>
		Arsenic	2.6E+00	7.0E-01	7.0E-01	9.7E+00	3E-01	3E-01	4E+00
		Lead*	3.4E-01	1.0E+00	1.0E+00	1.0E+00	-- (a)	-- (a)	-- (a)
		Mercury	2.0E-02	7.0E-02	4.0E-02	3.0E-02	4E+00	2E+00	2E+00
	WWC2	Zinc	4.5E+00	5.2E+01	3.7E+01	2.8E+01	1E+01	8E+00	6E+00
		<i>Sample Type</i>		<i>Forage</i>	<i>Game</i>	<i>Rough</i>	<i>Forage</i>	<i>Game</i>	<i>Rough</i>
		Arsenic	2.6E+00	7.7E+00	2.5E-01	3.4E+00	3E+00	1E-01	1E+00
		Lead	3.4E-01	1.0E+00	1.0E+00	1.0E+00	-- (a)	-- (a)	-- (a)
	WWC3	Mercury	2.0E-02	1.9E-01	1.8E-01	7.0E-02	1E+01	9E+00	4E+00
		Zinc	4.5E+00	4.7E+01	4.1E+00	1.3E+01	1E+01	9E-01	3E+00
		<i>Sample Type</i>		<i>Forage</i>	<i>Game</i>	<i>Rough</i>	<i>Forage</i>	<i>Game</i>	<i>Rough</i>
		Arsenic	2.6E+00	1.9E+00	1.0E+00	3.6E+00	7E-01	4E-01	1E+00
	WWC4	Lead	3.4E-01	1.0E+00	1.0E+00	1.0E+00	-- (a)	-- (a)	-- (a)
		Mercury	2.0E-02	1.1E-01	6.0E-02	9.0E-02	6E+00	3E+00	5E+00
		Zinc	4.5E+00	6.0E+01	4.4E+01	2.8E+01	1E+01	1E+01	6E+00
		<i>Sample Type</i>		<i>Forage</i>	<i>Game</i>	<i>Rough</i>	<i>Forage</i>	<i>Game</i>	<i>Rough</i>
	BFR1	Arsenic	2.6E+00	9.0E-01	2.5E-01	2.7E+00	3E-01	1E-01	1E+00
		Lead	3.4E-01	1.0E+00	1.0E+00	1.0E+00	-- (a)	-- (a)	-- (a)
		Mercury	2.0E-02	1.3E-01	1.2E-01	7.0E-02	7E+00	6E+00	4E+00
		Zinc	4.5E+00	3.4E+01	2.1E+01	1.6E+01	8E+00	5E+00	4E+00
	BFR2	<i>Sample Type</i>		<i>Forage</i>	<i>Game</i>	<i>Rough</i>	<i>Forage</i>	<i>Game</i>	<i>Rough</i>
		Arsenic	2.6E+00	8.0E-01	2.5E-01	1.9E+00	3E-01	1E-01	7E-01
		Lead	3.4E-01	1.0E+00	1.0E+00	1.0E+00	-- (a)	-- (a)	-- (a)
		Mercury	2.0E-02	2.0E-01	8.0E-02	7.0E-02	1E+01	4E+00	4E+00
ERT (2001a)	WWC-06	Zinc	4.5E+00	7.3E+01	1.7E+01	1.2E+01	2E+01	4E+00	3E+00
		<i>Sample Type</i>		<i>Rough</i>	<i>Rough</i>	<i>Rough</i>	<i>Rough</i>	<i>Rough</i>	<i>Rough</i>
		Arsenic	2.6E+00	7.9E-01	8.9E-01	6.0E-01	3E-01	3E-01	2E-01
		Cadmium	1.3E-01	8.4E-03	8.4E-03	8.4E-03	6E-02	6E-02	6E-02
		Copper	3.7E+00	1.5E+00	1.2E+00	1.3E+00	4E-01	3E-01	4E-01
		Lead	3.4E-01	8.4E-03	8.4E-03	8.4E-03	2E-02	2E-02	2E-02
		Mercury	2.0E-02	5.8E-02	5.0E-02	4.3E-02	3E+00	3E+00	2E+00
		Selenium	1.0E+00	1.2E+00	1.4E+00	1.1E+00	1E+00	1E+00	1E+00
	WWC-08	Zinc	4.5E+00	1.9E+01	2.3E+01	2.3E+01	4E+00	5E+00	5E+00
		<i>Sample Type</i>		<i>Forage</i>	<i>Rough</i>	<i>Rough</i>	<i>Forage</i>	<i>Rough</i>	<i>Rough</i>
		Arsenic	2.6E+00	2.1E-01	8.9E-01		8E-02	3E-01	
		Cadmium	1.3E-01	3.1E-02	9.6E-03		2E-01	7E-02	
		Copper	3.7E+00	8.2E-01	7.0E-01		2E-01	2E-01	
		Lead	3.4E-01	8.4E-03	9.6E-03		2E-02	3E-02	
		Mercury	2.0E-02	6.7E-02	1.2E-02		3E+00	6E-01	
		Selenium	1.0E+00	1.1E+00	4.6E-01		1E+00	5E-01	
	WWC-09	Zinc	4.5E+00	2.4E+01	2.4E+01		5E+00	5E+00	
		<i>Sample Type</i>		<i>Rough</i>	<i>Rough</i>	<i>Forage</i>	<i>Rough</i>	<i>Rough</i>	<i>Forage</i>
		Arsenic	2.6E+00	1.9E-01	4.1E-01	7.7E-01	7E-02	2E-01	3E-01
		Cadmium	1.3E-01	1.9E-02	8.4E-03	2.4E-02	1E-01	6E-02	2E-01
		Copper	3.7E+00	6.0E-01	5.5E-01	8.6E-01	2E-01	1E-01	2E-01
		Lead	3.4E-01	7.2E-03	8.4E-03	2.6E-02	2E-02	2E-02	8E-02
		Mercury	2.0E-02	7.2E-03	8.4E-03	5.0E-02	4E-01	4E-01	3E+00
		Selenium	1.0E+00	9.4E-01	9.1E-01	1.3E+00	9E-01	9E-01	1E+00
	BFR-10 Reference	Zinc	4.5E+00	2.3E+01	1.8E+01	1.9E+01	5E+00	4E+00	4E+00
		<i>Sample Type</i>		<i>Forage</i>	<i>Forage</i>	<i>Forage</i>	<i>Forage</i>	<i>Forage</i>	<i>Forage</i>
		Arsenic	2.6E+00	2.3E-01	2.3E-01	8.2E-01	9E-02	9E-02	3E-01
		Cadmium	1.3E-01	1.9E-02	9.6E-03	1.7E-02	1E-01	7E-02	1E-01
		Copper	3.7E+00	8.9E-01	6.5E-01	6.7E-01	2E-01	2E-01	2E-01
		Lead	3.4E-01	2.9E-02	5.8E-02	1.0E-01	8E-02	2E-01	3E-01
		Mercury	2.0E-02	9.6E-03	3.4E-02	8.4E-03	5E-01	2E+00	4E-01
		Selenium	1.0E+00	9.6E-01	1.1E+00	4.0E-01	1E+00	1E+00	4E-01
	BFR-11	Zinc	4.5E+00	2.8E+01	3.8E+01	2.4E+01	6E+00	8E+00	5E+00
		<i>Sample Type</i>		<i>Forage</i>	<i>Rough</i>	<i>Forage</i>	<i>Forage</i>	<i>Rough</i>	<i>Forage</i>
		Arsenic	2.6E+00	1.6E+00	6.0E-01	1.7E+00	6E-01	2E-01	6E-01
		Cadmium	1.3E-01	1.7E-02	2.2E-02	8.4E-03	1E-01	2E-01	6E-02
		Copper	3.7E+00	8.4E-01	1.1E+00	8.2E-01	2E-01	3E-01	2E-01
		Lead	3.4E-01	6.0E-02	4.8E-02	4.6E-02	2E-01	1E-01	1E-01
		Mercury	2.0E-02	3.8E-02	4.1E-02	6.0E-02	2E+00	2E+00	3E+00
		Selenium	1.0E+00	1.2E+00	1.0E+00	1.2E+00	1E+00	1E+00	1E+00
	SPC-R-12 Reference	Zinc	4.5E+00	3.0E+01	1.4E+01	4.4E+01	7E+00	3E+00	1E+01
		<i>Sample Type</i>		<i>Game</i>	<i>Game</i>	<i>Game</i>	<i>Game</i>	<i>Game</i>	<i>Game</i>
		Arsenic	2.6E+00	2.3E-01	2.4E-01	2.2E-01	9E-02	9E-02	9E-02
		Cadmium	1.3E-01	9.6E-03	9.6E-03	8.4E-03	7E-02	7E-02	6E-02
		Copper	3.7E+00	6.5E-01	6.2E-01	7.2E-01	2E-01	2E-01	2E-01
		Lead	3.4E-01	4.6E-02	3.8E-02	3.4E-02	1E-01	1E-01	1E-01
		Mercury	2.0E-02	1.1E-01	1.1E-01	9.6E-02	5E+00	6E+00	5E+00
		Selenium	1.0E+00	4.7E-01	4.7E-01	4.4E-01	5E-01	5E-01	4E-01
		Zinc	4.5E+00	5.3E+01	3.5E+01	3.4E+01	1E+01	8E+00	8E+00

(a) No HQ value is shown because lead was not detected in any samples, and the MATC for lead is lower than the detection limit

**Table 6-10**  
**Results of Sediment Toxicity Tests (*Hyaella azteca*)**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

		Laboratory Control	WWC-R-01 M	WWC-02	WWC-03	WWC-04	WWC-05	WWC-06	WWC-07	WWC-08	WWC-09	BFR-R-10	BFR-11	SPC-R-12
Toxicity Endpoints	Mean Survival, % (SE)	83.8 (1.8)	72.5 (8.0)	93.8 (4.2)	78.8 (4.0)	78.8 (4.0)	25.0 (8.0)	30.0 (9.6)	88.8 (4.8)	71.2 (7.2)	81.2 (4.4)	87.5 (4.1)	83.8 (5.0)	76.2 (11.5)
	Mean Length, mm (SE)	3.83 (0.12)	4.20 (0.17)	3.74 (0.17)	3.95 (0.27)	3.85 (0.22)	2.95 (0.43)	3.60 (0.63)	3.65 (0.16)	3.46 (0.24)	3.20 (0.10)	3.58 (0.19)	3.74 (0.14)	3.93 (0.53)
	Mean Change in Length, % (SE)	22.4 (3.8)	34.1 (5.3)	19.4 (5.4)	26.2 (8.5)	23.0 (7.0)	-5.6 (7.1)	15.2 (7.8)	16.6 (5.1)	10.5 (7.6)	2.4 (3.1)	14.6 (6.1)	19.4 (4.5)	25.5 (6.8)
Sediment Concentrations (mg/kg)	Arsenic		20	235	484	608	1150	1230	607	789	565	14	1400	14
	Cadmium		0.2	1.1	1.8	1.4	1.1	1.0	0.68	1.0	1.3	1.9	1.3	0.4
	Copper		8	43	93	109	55.2	48.9	33	34.8	36.5	20.6	31.1	6.8
	Lead		10.9	14.8	245	44.8	27.0	19.5	14.5	12.85	16.6	11.8	20.3	13.8
	Manganese		228	1130	1100	902	862.0	772	610	832.5	735	623	844	194
	Mercury		0.08	0.19	0.34	0.27	0.65	0.36	0.26	0.31	0.28	0.04	0.17	0.04
	Nickel		4	32.6	38.6	31.6	22.1	25.9	20.2	18.8	25.3	25.5	21.8	4.6
	Zinc		20.7	139	216	133	101	125	72.5	64	93.8	78.1	76.8	25.2
Pore Water Concentrations (ug/L)	Ammonia (mg/L)	0.011	0.05	0.082	0.071	0.077	0.842	0.223	0.068	0.042	0.05	0.028	0.109	0.241
	Arsenic	190	8.6	310	2200	500	7900	7100	1900	610	500	11	2400	120
	Cadmium	6	2.5	2.8	20	3.65	43	40	7.6	4.15	2.5	2.5	12	3.65
	Copper	350	5	18	1100	58	29	15	24	8.5	13	5	5	7.5
	Lead	1100	1.1	7.3	1900	37	11	4.9	9	4.7	4.8	5.8	2.7	8
	Manganese	9500	790	2200	14000	5000	2300	890	2100	6800	5100	2600	1400	630
	Mercury	--	--	--	--	--	--	--	--	--	--	--	--	--
	Nickel	220	5	20	360	22	5	5	5	8.5	24	20	5	7.5
	Zinc	1200	5	130	3200	79	45	5	28	22	40	40	10	20

  Denotes value is statistically significantly different from laboratory control ( $\alpha = 0.05$ ).  
 10 day exposure period.  
 Sample Size (N) = 8

**Table 6-11**  
**Correlation of COPCs with *Hyaella azteca* Toxicity**

*Ecological Risk Assessment for the Whitewood Creek Site*

Media	COPC	Mean Survival, %		Mean Length, mm		Mean Change in Length, %	
		p value	R	p value	R	p value	R
Sediment	Arsenic	0.065	-0.548	0.109	-0.486	0.108	-0.488
	Cadmium	0.666	0.139	0.372	-0.283	0.378	-0.280
	Copper	0.704	-0.123	0.893	-0.044	0.894	-0.043
	Lead	0.855	0.059	0.422	0.256	0.419	0.257
	Manganese	0.984	-0.006	0.316	-0.316	0.314	-0.318
	Mercury	<b>0.010</b>	<b>-0.708</b>	0.015	-0.681	0.015	-0.682
	Nickel	0.792	0.085	0.495	-0.219	0.498	-0.217
	Zinc	0.872	-0.052	0.849	-0.062	0.853	-0.060
Pore Water	Ammonia	<b>0.002</b>	<b>-0.781</b>	0.032	-0.594	0.032	-0.595
	Arsenic	<b>0.00004</b>	<b>-0.893</b>	0.06087	-0.533	0.06160	-0.531
	Cadmium	<b>0.00004</b>	<b>-0.895</b>	0.12017	-0.453	0.12189	-0.451
	Copper	0.704	0.117	0.332	0.293	0.330	0.294
	Lead	0.626	0.150	0.302	0.310	0.300	0.312
	Manganese	0.483	0.214	0.759	0.094	0.758	0.095
	Mercury	na	na	na	na	na	na
	Nickel	0.552	0.182	0.317	0.302	0.314	0.303
	Zinc	0.644	0.142	0.321	0.299	0.319	0.300

**Table 6-12a**  
**Seep Water Concentrations and Hazard Quotients**  
**Data from USGS (2000)**  
*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*

Location ID	Analyte	Conc. (ug/L)	Total Ambient Water Quality Criteria (ug/L) (a)		HQ	
			Acute	Chronic	Acute	Chronic
USGS (2000) 23R  Whitewood Creek above Vale Rd	Arsenic	91	340	150	3E-01	6E-01
	Cadmium	0.1	7.8	0.58	1E-02	2E-01
	Chromium	2.0	16.0	11.00	1E-01	2E-01
	Copper	1.0	51.7	17.6	2E-02	6E-02
	Lead	0.10	417	5.3	2E-04	2E-02
	Mercury	0.003	1.4	0.8	2E-03	4E-03
	Nickel	13	1387	97.7	9E-03	1E-01
	Selenium	1.0	19.3	5.0	5E-02	2E-01
	Zinc	4.5	355	225	1E-02	2E-02
USGS (2000) 23L  Whitewood Creek above Vale Rd	Arsenic	410	340	150	1E+00	3E+00
	Cadmium	0.1	7.8	0.58	1E-02	2E-01
	Chromium	1.0	16.0	11.00	6E-02	9E-02
	Copper	0.5	51.7	17.6	9E-03	3E-02
	Lead	0.20	417	5.3	5E-04	4E-02
	Mercury	0.0002	1.4	0.8	1E-04	2E-04
	Nickel	11	1387	97.7	8E-03	1E-01
	Selenium	0.5	19.3	5.0	3E-02	1E-01
	Zinc	10	355	225	3E-02	4E-02
USGS (2000) 31L  Whitewood Creek above Vale Rd	Arsenic	420	340	150	1E+00	3E+00
	Cadmium	0.1	7.8	0.58	1E-02	2E-01
	Chromium	0.5	16.0	11.00	3E-02	5E-02
	Copper	0.5	51.7	17.6	9E-03	3E-02
	Lead	0.10	417	5.3	2E-04	2E-02
	Mercury	0.001	1.4	0.8	1E-03	2E-03
	Nickel	22	1387	97.7	2E-02	2E-01
	Selenium	0.5	19.3	5.0	3E-02	1E-01
	Zinc	10	355	225	3E-02	4E-02
USGS (2000) 32L WWC - Site  Whitewood Creek below Vale Rd	Arsenic	40	340	150	1E-01	3E-01
	Cadmium	0.1	7.8	0.58	1E-02	2E-01
	Chromium	2.0	16.0	11.00	1E-01	2E-01
	Copper	0.5	51.7	17.6	9E-03	3E-02
	Lead	0.10	417	5.3	2E-04	2E-02
	Mercury	0.011	1.4	0.8	8E-03	1E-02
	Nickel	12	1387	97.7	9E-03	1E-01
	Selenium	0.5	19.3	5.0	3E-02	1E-01
	Zinc	4.5	355	225	1E-02	2E-02
USGS (2000) 33L  Whitewood Creek below Vale Rd	Arsenic	850	340	150	3E+00	6E+00
	Cadmium	0.1	7.8	0.58	1E-02	2E-01
	Chromium	2.0	16.0	11.00	1E-01	2E-01
	Copper	0.5	51.7	17.6	9E-03	3E-02
	Lead	0.10	417	5.3	2E-04	2E-02
	Mercury	0.035	1.4	0.8	3E-02	5E-02
	Nickel	5.0	1387	97.7	4E-03	5E-02
	Selenium	0.5	19.3	5.0	3E-02	1E-01
	Zinc	10	355	225	3E-02	4E-02

(a) For all samples, measured hardness is greater than the upper hardness limit, therefore the applicable hardness limit was used to calculate the AWQC.  
Non-detects were evaluated at 1/2 of the detection limit.

**Table 6-12b**  
**Seep Water Concentrations and Hazard Quotients**  
**Data from ERT (USEPA 1999)**  
*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*

Location ID	Analyte	Conc. (ug/L)	Total Ambient Water Quality Criteria (ug/L) (a)		HQ	
			Acute	Chronic	Acute	Chronic
WWC-06	Aluminum	12.5	750.0	87	2E-02	1E-01
	Arsenic	274.0	340.0	150	8E-01	2E+00
	Copper	6.6	51.7	18	1E-01	4E-01
	Lead	32.1	417.0	5	8E-02	6E+00
	Mercury	0.1	1.4	0.77	4E-02	6E-02
	Nickel	1.5	1386.6	97.7	1E-03	2E-02
	Selenium	3.7	19.3	5.0	2E-01	7E-01
	Zinc	5.5	355	225	2E-02	2E-02
WWC-07	Aluminum	12.5	750.0	87	2E-02	1E-01
	Arsenic	852.0	340.0	150	3E+00	6E+00
	Copper	0.5	51.7	18	1E-02	3E-02
	Lead	1.0	417.0	5	2E-03	2E-01
	Mercury	0.1	1.4	0.77	4E-02	6E-02
	Nickel	7.1	1386.6	97.7	5E-03	7E-02
	Selenium	1.5	19.3	5.0	8E-02	3E-01
	Zinc	5.5	355	225	2E-02	2E-02
WWC-08	Aluminum	191.55	750.0	87	3E-01	2E+00
	Arsenic	79.0	340.0	150	2E-01	5E-01
	Copper	0.5	51.7	18	1E-02	3E-02
	Lead	1.0	417.0	5	2E-03	2E-01
	Mercury	0.1	1.4	0.77	1E-01	2E-01
	Nickel	6.6	1386.6	97.7	5E-03	7E-02
	Selenium	2.1	19.3	5.0	1E-01	4E-01
	Zinc	6.5	355	225	2E-02	3E-02
WWC-09	Aluminum	143.6	750.0	87	2E-01	2E+00
	Arsenic	261.4	340.0	150	8E-01	2E+00
	Copper	0.86	51.7	18	2E-02	5E-02
	Lead	2.2	417.0	5	5E-03	4E-01
	Mercury	0.1	1.4	0.77	7E-02	1E-01
	Nickel	2.6	1386.6	97.7	2E-03	3E-02
	Selenium	1.500	19.3	5.0	8E-02	3E-01
	Zinc	7.8	355	225	2E-02	3E-02

(a) For all samples, measured hardness is outside of the specified hardness limits, therefore the applicable hardness limit was used to calculate the AWQC.  
Non-detects were evaluated at 1/2 of the detection limit.

**Table 6-13**  
**Upstream-Downstream Comparison Near Seeps**

*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*

Location ID	Analyte	Initial Seep Water Concentrations (Total) (ug/L)		Total Ambient Water Quality Criteria (ug/L) (a)		Hazard Quotients (HQs)			
		Above seep	Mixing zone	Acute	Chronic	Above Seep		Mixing Zone	
						Acute	Chronic	Acute	Chronic
USGS (2000) 23R  Whitewood Creek above Vale Rd	Arsenic	31	46	340	150	9E-02	2E-01	1E-01	3E-01
	Cadmium	0.1	0.1	7.8	0.58	1E-02	2E-01	1E-02	2E-01
	Chromium	2.0	2	16.0	11.00	1E-01	2E-01	1E-01	2E-01
	Copper	2.0	0.45	51.7	17.6	4E-02	1E-01	9E-03	3E-02
	Lead	0.10	0.3	417	5.3	2E-04	2E-02	7E-04	6E-02
	Mercury	0.009	0.00246	1.4	0.8	6E-03	1E-02	2E-03	3E-03
	Nickel	1.5	16	1387	97.7	1E-03	2E-02	1E-02	2E-01
	Selenium	2.0	0.5	19.3	5.0	1E-01	4E-01	3E-02	1E-01
	Zinc	4.5	10	355	225	1E-02	2E-02	3E-02	4E-02
USGS (2000) 23L  Whitewood Creek above Vale Rd	Arsenic	34	110	340	150	1E-01	2E-01	3E-01	7E-01
	Cadmium	0.1	0.1	7.8	0.58	1E-02	2E-01	1E-02	2E-01
	Chromium	2.0	4	16.0	11.00	1E-01	2E-01	3E-01	4E-01
	Copper	2.0	2	51.7	17.6	4E-02	1E-01	4E-02	1E-01
	Lead	0.20	0.4	417	5.3	5E-04	4E-02	1E-03	8E-02
	Mercury	0.012	0.02529	1.4	0.8	8E-03	2E-02	2E-02	3E-02
	Nickel	1.5	5	1387	97.7	1E-03	2E-02	4E-03	5E-02
	Selenium	1.0	0.5	19.3	5.0	5E-02	2E-01	3E-02	1E-01
	Zinc	4.5	10	355	225	1E-02	2E-02	3E-02	4E-02
USGS (2000) 31L  Whitewood Creek above Vale Rd	Arsenic	31	170	340	150	9E-02	2E-01	5E-01	1E+00
	Cadmium	0.1	0.1	7.8	0.58	1E-02	2E-01	1E-02	2E-01
	Chromium	1.0	2	16.0	11.00	6E-02	9E-02	1E-01	2E-01
	Copper	1.0	2	51.7	17.6	2E-02	6E-02	4E-02	1E-01
	Lead	0.10	0.6	417	5.3	2E-04	2E-02	1E-03	1E-01
	Mercury	0.019	0.00627	1.4	0.8	1E-02	3E-02	4E-03	8E-03
	Nickel	1.5	8	1387	97.7	1E-03	2E-02	6E-03	8E-02
	Selenium	1.0	0.5	19.3	5.0	5E-02	2E-01	3E-02	1E-01
	Zinc	4.5	9	355	225	1E-02	2E-02	3E-02	4E-02
USGS (2000) 32L  Whitewood Creek below Vale Rd	Arsenic	28	29	340	150	8E-02	2E-01	9E-02	2E-01
	Cadmium	0.1	0.1	7.8	0.58	1E-02	2E-01	1E-02	2E-01
	Chromium	2.0	3	16.0	11.00	1E-01	2E-01	2E-01	3E-01
	Copper	0.5	0.45	51.7	17.6	9E-03	3E-02	9E-03	3E-02
	Lead	0.10	0.6	417	5.3	2E-04	2E-02	1E-03	1E-01
	Mercury	0.016	0.02197	1.4	0.8	1E-02	2E-02	2E-02	3E-02
	Nickel	4.0	5	1387	97.7	3E-03	4E-02	4E-03	5E-02
	Selenium	2.0	1	19.3	5.0	1E-01	4E-01	5E-02	2E-01
	Zinc	4.5	10	355	225	1E-02	2E-02	3E-02	4E-02
USGS (2000) 33L  Whitewood Creek below Vale Rd	Arsenic	32	120	340	150	9E-02	2E-01	4E-01	8E-01
	Cadmium	0.1	0.1	7.8	0.58	1E-02	2E-01	1E-02	2E-01
	Chromium	3.0	7	16.0	11.00	2E-01	3E-01	4E-01	6E-01
	Copper	0.5	2	51.7	17.6	9E-03	3E-02	4E-02	1E-01
	Lead	0.50	2.9	417	5.3	1E-03	9E-02	7E-03	5E-01
	Mercury	0.021	0.03934	1.4	0.8	1E-02	3E-02	3E-02	5E-02
	Nickel	4.0	9	1387	97.7	3E-03	4E-02	6E-03	9E-02
	Selenium	1.0	1	19.3	5.0	5E-02	2E-01	5E-02	2E-01
	Zinc	9.0	35	355	225	3E-02	4E-02	1E-01	2E-01

(a) For all samples, measured hardness is greater than the upper hardness limit, therefore the applicable hardness limit was used to calculate the AWQC. Non-detects were evaluated at 1/2 of the detection limit.

Shaded cells indicate locations where the concentration downstream is more than 50% higher than upstream

**Table 6-14**  
**Mean Survival of Fathead Minnow Exposed to Seep Water**

*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*

Seep Site	Location	Mean Survival (%) Exposure Period			
		24 hours	48 hours	72 hours	96 hours
23 R	Above Seep	100 (0)	100 (0)	100 (0)	100 (0)
	Seep	93 (7)	90 (10)	97 (3)	87 (3)
	Mixing Zone	97 (3)	97 (3)	97 (3)	87 (3)
23 L	Above Seep	100 (0)	100 (0)	100 (0)	97 (3)
	Seep	97 (3)	97 (3)	97 (3)	97 (3)
	Mixing Zone	100 (0)	97 (3)	97 (3)	97 (3)
31 L	Above Seep	100 (0)	100 (0)	100 (0)	100 (0)
	Seep	97 (3)	97 (3)	97 (3)	90 (6)
	Mixing Zone	97 (3)	97 (3)	97 (3)	97 (3)
32 L	Above Seep	100 (0)	100 (0)	100 (0)	100 (0)
	Seep	100 (0)	100 (0)	100 (0)	100 (0)
	Mixing Zone	100 (0)	100 (0)	100 (0)	100 (0)
33 L	Above Seep	100 (0)	100 (0)	100 (0)	100 (0)
	Seep	93 (3)	93 (3)	93 (3)	93 (3)
	Mixing Zone	97 (3)	97 (3)	97 (3)	93 (3)
Reference	Reference	97 (3)	97 (3)	97 (3)	97 (3)

Standard error in parentheses, N = 3.

Source: Hamilton and Buhl, 1999. *The toxicity to fathead minnow of seep waters along Whitewood Creek, South Dakota.*

**Table 6-15. Summary of Aquatic Community Studies**

Reference	Study Period	Study Locations		Communities Studied			Author's Conclusion	Notes
		Site	Reference	Fish	BMI	Algae		
Herricks 1982	March 1981-May 1982	12 sites on WWC	2 sites on Spearfish, 1 site on Sand Creek	X	X		Fish are limited by high summer temperatures and "toxic barrier" associated with mine discharge; BMI community is significantly impacted by the discharges from Gold Run	Data were collected before water treatment facility became operational, and are not relevant to current conditions
Fox 1984a	July 1983	8 sites on WWC, 1 site on BFR	1 site on BFR, 1 site on Spearfish Creek, 1 on False Bottom Creek	X	X	X	Fish are non-existent between Crook City and Crow Creek and poorly developed downstream to BFR primarily due to temperature, flow and water quality. Impacts to BMI communities are not stated. Periphyton coverage decreases from upstream to downstream WWC.	Data were collected before water treatment facility became operational, and are not relevant to current conditions
Chadwick 1990, 1997	seasonal 1989, spring 1990, seasonal 1996	4 sites on WWC, 1 site on BFR	None for WWC; 1 site on BFR	X	X	X	BMI communities are relatively diverse and show no discernible effects from tailings. Fish and periphyton communities in WWC are healthy and diverse.	
Chadwick 2001	April 200, Sept 2000	4 sites on WWC	1 site on Spearfish Creek	X	X		Healthy populations, little evidence of stress.	Differences in habitat make Spearfish Creek site questionable as a reference site
Knudson 2000, 2001a, 2001b	June and September 1998, 1999, 2000	4 sites on WWC below Gold Run	1 site on WWC (upstream of Gold Run)	X	X	X	Aquatic populations and communities were essentially recovered by June 2000 from effects of process spill in May 1998; low BMI ratings may be due to habitat	Main purpose was to evaluate effects of process spill in May 1998
EPA 2001a	March 1999	8 sites on WWC below Gold Run, 1 site on BFR	1 site on WWC (upstream of Gold Run), 1 site on BFR, 1 site on Spearfish Creek		X		Benthic communities are categorized as slightly impaired compared to site reference locations.	Habitat at upstream BFR may be impacted due to wastewater treatment facility located upstream of sampling location.

WWC = Whitewood Creek

BFR = Belle Fourche River

BMI = Benthic macroinvertebrate

**Table 6-16 Summary of Benthic Matrices for Whitewood Creek, Belle Fouce River, and Spearfish Creek**

*Ecological Risk Assessment  
Whitewood Creek, Lead, South Dakota*

	WWC-R-01	WWC-02	WWC-03	WWC-04	WWC-05	WWC-06	WWC-08	WWC-09	BFR-R-10	BFR-11	SPC-R-12
Number of Organisms per Sample (Average)	4500	7568	1486	1035	1810	675	296	739	91	55	2231
Number of Taxa per Location (Taxa richness)	42	30	29	19	18	17	17	23	9	11	31
Ratio of Scrapers to Filterers	7.5	2	6.9	3.3	4.1	1.5	0.9	1.2	3.9	0.5	0.6
EPT Abundance	11483	17214	2718	2031	3046	1270	494	987	6	35	2413
Chironomid Abundance per Location	1026	3540	1581	1049	2008	492	215	671	200	38	1372
EPTto Chironomid Ratio (Abundance)	11.2	4.9	1.7	1.9	1.5	2.6	2.3	1.5	0.0	0.9	1.8
(EPT) to (E+P+T+C) Ratio	0.9	0.8	0.6	0.7	0.6	0.7	0.7	0.6	0.0	0.5	0.6
% Contribution of Dominant Taxon (Average)	49.1	36.5	38.6	57.5	48.9	33.5	33.6	33	67.3	40.4	30.6
EPT Index per Location	20	18	18	10	10	8	8	9	3	5	12
H <sup>1</sup> Diversity (Average) Shannon	1.6	1.7	1.8	1.2	1.3	1.8	1.9	1.9	1	1.5	2.1
Hillsenhoff's Biotic Index (Average)	4.7	4.6	4.5	5.1	5.1	4.7	4.6	4.5	5.5	5.3	4.4
<b>Community Loss Index</b>											
Relative to WWC-R-01		0.57	0.62								
Relative to SPC-R-12				0.79	0.89	1.00	1.00	0.70			
Relative to BFR-R-10										0.33	
<b>Biological Condition Score</b>											
Relative to WWC-R-01		67	72								
Relative to SPC-R-12				79	74	68	68	79			
Relative to BFR-R-10										78	
<b>Biological Condition Category</b>											
Relative to WWC-R-01		Slightly Impaired	Slightly Impaired								
Relative to SPC-R-12				Slightly Impaired	Slightly Impaired	Slightly Impaired	Slightly Impaired	Slightly Impaired			
Relative to BFR-R-10										Slightly Impaired	

NA = Comparisons were not made.

**Table 6-17 Correlation of COPC Concentrations with Benthic Macroinvertebrate Metrics**  
*Ecological Risk Assessment for the Whitewood Creek Site, South Dakota*

Medium	COPC	Number of Organisms per Sample (Average)		Number of Taxa per Location		EPT Abundance per Location		Chironomid Abundance per Location		EPT: Chironomid Ratio		% Contribution Dominant Taxa (Average)		EPT Index per Location		H <sup>1</sup> Diversity (Average)		Hillsenhoff's Biotic Index (Average)		Total Score	
		p value	R	p value	R	p value	R	p value	R	p value	R	p value	R	p value	R	p value	R	p value	R	p value	R
Sediment	Arsenic	0.16	-0.45	0.07	-0.57	0.20	-0.42	0.42	-0.27	0.26	-0.37	0.50	-0.23	0.18	-0.44	0.88	-0.05	0.44	0.26	0.12	-0.49
	Cadmium	0.22	-0.40	0.04	-0.63	0.25	-0.38	0.73	-0.12	0.02	-0.67	0.22	0.40	0.22	-0.40	0.12	-0.49	0.14	0.47	0.48	-0.24
	Copper	0.67	-0.14	0.64	-0.16	0.69	-0.13	0.56	0.20	0.38	-0.30	0.63	0.17	0.75	0.11	0.46	-0.25	0.85	0.06	0.64	0.16
	Lead	0.81	-0.08	0.58	0.19	0.78	-0.09	0.63	0.16	0.66	-0.15	0.84	-0.07	0.22	0.40	0.73	0.12	0.48	-0.24	0.33	0.33
	Manganese	0.90	0.04	0.27	-0.36	0.85	0.06	0.31	0.34	0.25	-0.38	0.92	-0.04	0.98	-0.01	0.60	-0.18	0.74	0.11	0.48	-0.24
	Mercury	0.62	-0.17	0.49	-0.23	0.61	-0.17	0.55	0.20	0.47	-0.25	0.72	-0.12	0.92	-0.03	0.84	-0.07	0.99	-0.01	0.44	-0.26
	Nickel	0.86	-0.06	0.26	-0.37	0.91	-0.04	0.46	0.25	0.16	-0.46	0.69	0.13	0.88	-0.05	0.40	-0.28	0.63	0.16	0.73	-0.12
	Zinc	0.94	0.03	0.74	-0.11	0.94	0.03	0.28	0.36	0.34	-0.32	0.95	-0.02	0.55	0.20	0.80	-0.09	0.84	-0.07	0.80	0.09
Surface Water	Aluminum	0.63	-0.16	0.95	0.02	0.62	-0.17	0.68	-0.14	0.69	-0.14	0.42	-0.27	0.72	-0.12	0.41	0.28	0.39	-0.29	0.25	-0.38
	Copper	0.58	-0.19	0.91	-0.04	0.58	-0.19	0.67	0.15	0.63	-0.17	0.86	0.06	0.68	0.14	0.70	-0.13	0.84	-0.07	0.82	0.08
	Cyanide	0.75	-0.11	0.64	0.16	0.74	-0.11	0.66	0.15	0.65	-0.16	0.94	0.02	0.25	0.38	0.93	0.03	0.58	-0.19	0.26	0.38
	Hardness	0.00	-0.83	0.00	-0.80	0.00	-0.79	0.02	-0.70	0.02	-0.69	0.74	0.11	0.00	-0.80	0.52	-0.22	0.20	0.42	0.01	-0.76
	Lead	0.63	0.16	0.95	-0.02	0.62	0.17	0.68	0.14	0.69	0.14	0.42	0.27	0.72	0.12	0.41	-0.28	0.39	0.29	0.25	0.38
	Selenium	0.91	-0.04	0.67	-0.14	0.84	-0.07	0.96	0.02	0.87	-0.05	0.69	-0.14	0.82	-0.08	0.83	0.07	0.92	0.04	0.80	0.09
	Silver	0.87	0.06	0.41	0.28	0.87	0.06	0.72	-0.12	0.49	0.24	0.11	-0.51	0.83	0.07	0.06	0.59	0.04	-0.62	0.23	-0.39

**Table 6-18 Summary of Bioassessment Protocol Habitat Scores for Whitewood Creek, Belle Fouce River, and Spearfish Creek**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

Habitat Parameter	WWC-R-01	WWC-02	WWC-03	WWC-04	WWC-05	WWC-06	WWC-07	WWC-08	WWC-09	BFR-R-10	BFR-11	SPC-R-12
Epifaunal Substrate/ Available Cover	18	18	18	16	14	13	13	6	11	11	13	16
Embeddedness	18	16	18	16	15	14	14	10	13	9	8	15
Velocity-Depth Regime	18	18	18	18	16	15	18	16	18	14	13	16
Sediment Deposition	16	15	16	18	11	8	8	3	8	11	13	17
Channel Flow Status	16	18	18	17	15	8	8	13	9	17	16	18
Channel Alteration	13	16	13	18	18	14	13	12	12	16	17	18
Frequency of Riffles (or Bends)	18	18	18	18	17	18	18	13	17	8	8	18
Bank Stability - left bank	8	4	8	8	2	2	4	1	2	8	7	9
Bank Stability - right bank	8	7	9	9	4	4	7	3	4	8	7	9
Bank Vegetative Protection - left bank	8	5	6	4	6	6	5	3	4	4	5	7
Bank Vegetative Protection - right bank	8	4	5	4	5	6	7	5	1	4	5	7
Riparian Vegetative Zone Width - left bank	8	5	7	4	7	4	7	2	4	8	6	7
Riparian Vegetative Zone Width - right bank	8	3	4	7	6	4	7	3	4	8	6	7
<b>Total Score</b>	<b>165</b>	<b>147</b>	<b>158</b>	<b>157</b>	<b>136</b>	<b>116</b>	<b>129</b>	<b>90</b>	<b>107</b>	<b>126</b>	<b>124</b>	<b>164</b>
Comparability to WWC-R-01		0.89	0.96									
Comparability to SPC-R-12				0.96	0.83	0.71	0.79	0.55	0.65			
Comparability to BFR-R-10											0.98	
<b>Classification</b>		Supporting	Comparable	Comparable	Supporting	Partially Supporting	Supporting	Non Supporting	Partially Supporting		Comparable	

**Table 6-19. Comparison of BMI Communities in Whitewood Creek Below Gold Run with Whitewood Creek Reference Location**

Date	Station	Taxa Richness			% Contribution of Dominant Taxon			Community Loss			Biological Condition		
		# of Taxa	% of WC-1	Score	# Dom Taxon/Total Taxa	% of Total taxa	Score	# of common taxa	Comm. Loss Index	Score	Total Score	% of WC-1	Biological Condition Rating
June 2000	WC-1	28	[100%]	6	961/2605	37%	2	--	--	6	14	[100%]	[Reference]
	WC-2	26	93%	6	1204/2085	58%	0	23	0.19	6	12	86%	Non-impaired
	GFP-8	24	86%	6	2187/2751	79%	0	17	0.46	6	12	86%	Non-impaired
	GFP-1	29	104%	6	1914/3435	56%	0	20	0.26	6	12	86%	Non-impaired
Sept. 2000	WC-1	30	[100%]	6	347/1913	18%	6	--	--	6	18	--	[Reference]
	WC-2	25	83%	6	1287/3433	38%	2	17	0.52	4	12	67%	Slightly impaired
	GFP-8	26	87%	6	1007/2574	39%	2	15	0.57	4	12	67%	Slightly impaired
	GFP-1	29	97%	6	782/3252	24%	4	15	0.52	4	14	78%	Slightly impaired

Source: Knudson (2201a, 2001b)

**Table 7-1**  
**Surface Soil Data Used in the ERA**

*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*

Station	Replicate ID	Soil Concentration (mg/kg dw)																									
		Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Calcium	Chromium	Cobalt	Copper	Cyanide	Iron	Lead	Magnesium	Manganese	Mercury	Molybdenum	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
		March-99																									
WWC-R-01 M*	--	1,800	92.1	948	857	1	11.2	0.88	14,700	7.8	16.5	78.9	1 U	29,400	42.6	1,490	1,260	4	5	13.8	710	1.1	7.4	76 U	5.4	124	309
WWC-05	--	3,220	2.5	1,100	89.6	0.7	3.6	1.1	10,700	10	9.1	35.8	0.6 U	38,700	18.9	4,170	587	0.26	2	17.9	1,010	1	0.45	25 U	0.7 U	20.2	82.5
WWC-06	--	4,410	3.9	1,200	123	1	9	0.97	10,400	10.1	11.4	42	0.82	54,000	19.9	4,220	714	0.22	7	21.2	1,050	1.3	0.32	27.6	0.68 U	28.7	74.9
WWC-07	--	6,710	0.74 U	1,400	137	0.81	6.8	0.96	19,000	12.1	11.5	45.1	0.6 U	54,100	18.3	6,820	998	0.34	2	21.7	1,780	1.6	0.16	26.2 U	0.74 U	26.8	70.9
WWC-08	--	5,990	1.2	1,200	143	0.71	5	1.1	19,000	11.6	10.4	42.1	0.64 U	52,300	31.1	7,290	953	0.31	2	19.5	1,620	1.5	0.18	24.4 U	0.69 U	25.7	63.7
WWC-09	--	7,890	0.79 U	2,610	146	0.68	6.1	1.3	5,350	12.6	12.5	53.6	0.52 U	82,800	17.4	5,960	1,270	0.97	1	18.7	2,640	2.9	0.51	28 U	0.79 U	27.9	64.5
BFR-R-10	--	9,540	0.81 U	13.4	171	1	15.4	1.4	32,400	12.3	9.2	25.9	0.52 U	20,000	15.7	4,360	639	0.06 U	3.4	27.9	2,420	1.9	0.14 U	28.8 U	0.81 U	38	85.6
SPC-R-12	--	4,270	0.77 U	29.9	118	0.65	9.2	0.37	121,000	7.9	3.8	10.8	0.6 U	8,350	26.9	20,900	341	0.18	0.76	7.8	1,510	0.39 U	0.13 U	70.2	0.77 U	16.3	40.8
		August-99																									
WWC-R-01 A	01-06	6,400	6 U	0.6 U	140	0.6	10	1.5 U	23,000	8	6	11	na	12,000	20	8,000	440	1	1.1 U	7	1,400	3.1 U	0.8 U	31 U	0.6 U	16	36
	04-01	6,300	7.7 U	0.3 U	130	0.5	4	1.3 U	5,800	8	3	9	na	7,500	10	2,300	140	0.01 U	0.9 U	9	890	2.6 U	0.6 U	26 U	0.5 U	13	40
	04-09	10,000	6 U	0.6 U	310	2	3 U	1.5 U	8,700	11	5	14	na	11,000	20	2,400	430	0.02 U	1 U	13	1,100	3 U	0.7 U	30 U	0.6 U	17	45
	06-10	8,700	8 U	0.5 U	310	5	3 U	1.3 U	5,700	14	4	14	na	9,100	20	1,900	290	0.01 U	0.9 U	10	970	2.6 U	0.7 U	26 U	0.5 U	15	32
	07-02	11,000	8 U	0.5 U	240	1	5	1.3 U	4,600	12	7	14	na	12,000	20	2,400	490	0.01 U	0.9 U	13	1,400	2.6 U	0.7 U	26 U	0.5 U	20	51
WWC-05	--	3,900	6 U	1,800	130	0.3	7	0.6 U	12,000	10	12	44	na	46,000	28	5,500	980	0.3	2	22	1,100	2.2 U	1	110	0.8	25	73
	01-24	3,700	9	3,600	130	0.2 U	14	0.7 U	11,000	8	12	37	na	43,000	24	5,200	970	0.5	1	18	1,400	3	1	45	0.7	16	68
	01-42	3,700	6.5 U	1,000	130	0.6	8	0.7 U	11,000	10	9	29	na	49,000	20	4,900	700	0.3	2	19	1,100	2.2 U	1	63	0.7	26	83
	02-23	11,000	8.6 U	1,500	300	0.9	12	0.9 U	31,000	22	19	98	na	53,000	58	14,000	1,800	1	1	42	3,300	2.9 U	2	140	2	37	167
	02-32	11,000	8	3,500	170	0.4	11	0.7	8,500	20	14	70	na	82,000	30	11,000	1,800	1	1	22	2,900	3	2	59	0.9	33	90
WWC-06	--	7,600	9	3,900	120	0.4	6	2.4	5,100	12	5	85	na	85,000	20	3,900	470	0.2	0.8 U	7	2,600	5	1	98	0.8	21	53
	01-18	4,500	6.8 U	2,700	93	0.2 U	9	0.7 U	3,700	7	7	39	na	4,900	10	4,100	1,100	2	0.8 U	8	1,600	2	1	28	0.6	13	58
	02-05	7,400	6.8 U	1,900	200	0.4	8	0.7 U	24,000	14	15	68	na	48,000	32	11,000	1,400	2	0.8 U	28	2,400	3	2	77	2	26	100
	02-07	19,000	16	8,600	210	0.3	11	3.9 U	16,000	23	19	140	na	120,000	38	8,100	990	2	0.9 U	26	3,600	10	3	220	1	52	78
	02-15	9,800	7	3,240	180	0.4	9	1.1 U	11,000	17	14	75	na	74,000	30	11,000	1,800	0.9	0.8 U	22	2,600	3	2	59	1	29	86
WWC-08	01-02	3,900	6.6 U	3,400	90	0.2 U	9	2.2 U	3,000	7	8	34	na	54,000	10	2,500	730	1	0.8 U	8	1,600	3	2	42	1	16	62
	01-06	8,600	9	2,800	150	0.2 U	6	2.4 U	1,100	13	9	50	na	79,000	10	4,700	1,200	1	0.9 U	7	3,300	4	1	47	1	26	65
	01-20	6,000	7.3	960	120	0.3	8	2.4	16,000	10	10	30	na	45,000	10	5,900	920	0.01	1	16	1,000	2.4	0.7	24	0.8	21	57
	03-06	10,000	10	2,500	160	0.3	8	2.1	1,800	15	7	65	na	8,200	10	5,800	980	1	0.8 U	10	4,200	4	1	80	0.9	27	66
	06-17	14,000	7	920	190	0.5	7	1.2 U	1,000	18	10	56	na	83,000	20	7,500	2,800	1	0.8 U	16	3,700	2.3 U	2	30	2	36	92
SPC-R-12	--	2,700	6.9	0.4 U	99	0.2	7	2.1 U	110,000	5	3	5	na	5,000	20	19,000	250	2	0.8 U	7	620	2.3	0.6	110	0.5	11	32
	03-01	3,200	6.6 U	0.4 U	120	0.4	9	2.1	120,000	6	3	6	na	6,200	22	19,000	290	0.01 U	0.8 U	8	640	2.2 U	0.6 U	21	0.4 U	13	31
	04-01	2,500	6.6	0.4	110	0.2 U	8	1.1 U	130,000	4	3	4	na	5,200	23	20,000	250	0.01 U	0.8 U	6	530	2.2 U	0.6	110	0.4 U	11	27
	06-01	2,900	6.9 U	22	120	0.2 U	8	1.1	120,000	5	3	6	na	6,200	28	20,000	280	0.01 U	0.8	5	710	2.3 U	0.6 U	23 U	0.5 U	13	31
	10-01	2,300	6.9	0.5	110	0.2	8	0.7	120,000	4	2	5	na	5,000	20	18,000	240	0.01	0.7	6	640	2.3	0.6	23	0.5	11	31

U = Not detected

J = Estimated

B = Analyte found in blank

na = Not Analyzed

\* Sample collected near tailings.

**Table 7-2**  
**Phytotoxicity Benchmarks for Terrestrial Vegetation**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

Analyte	CH2MHill, 1987a & CH2MHill, 1987b	Efroymson et al., 1997	Kabata-Pendias & Pendias, 1992 <sup>a</sup>	Geomean of all values (mg/kg dw)
<b>Aluminum</b>	NA	50	NA	50
<b>Antimony</b>	NA	5	NA	5
<b>Arsenic</b>	100	10	15 to 50 (27.4)	10
<b>Barium</b>	NA	500	NA	500
<b>Boron</b>	NA	0.5	NA	0.5
<b>Chromium</b>	NA	1	1 to 2	1
<b>Copper</b>	100	100	60 to 125 (86.6)	60
<b>Iron</b>	NA	NA	NA	NA
<b>Lead</b>	1000	50	100 to 400 (200)	50
<b>Manganese</b>	NA	500	NA	500
<b>Mercury</b>	NA	35	5	5
<b>Molybdenum</b>	NA	2	135	2
<b>Nickel</b>	NA	30	NA	30
<b>Silver</b>	2	2	NA	2
<b>Thallium</b>	NA	1	NA	1
<b>Vanadium</b>	NA	2	NA	2
<b>Zinc</b>	500	50	70 to 400 (167)	50

All units are mg/kg dry weight.

NA = Not Available

a Value presented in parentheses is the geomean of the presented range.

Sources:

CH2MHill. 1987a. Assessment of the Toxicity of Arsenic, Cadmium, Lead and Zinc in Soil, Plants and Livestock in the Helena Valley of Montana for East Helena Site (ASARCO), East Helena, Montana.

CH2MHill. 1987b. Assessment of the Toxicity of Copper, Mercury, Selenium, Silver and Thallium in Soil, Plants and Livestock in the Helena Valley of Montana for East Helena Site (ASARCO), East Helena, Montana.

Efroymson et al., 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision.

Kabata-Pendias, A. and H. Pendias. 1992. Trace Elements in Soils and Plants, 2nd Edition.

**Table 7-3**  
**Seep Water Hazard Quotients (HQs) for Terrestrial Plants**

*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*

COPC	TRV (ug/L)	USGS (2000)												USEPA (2001a)							
		23L		23R		31L		32L		33L		Reference		WWC-06		WWC-07		WWC-08		WWC-09	
		Conc (ug/L)	HQ	Conc (ug/L)	HQ	Conc (ug/L)	HQ	Conc (ug/L)	HQ	Conc (ug/L)	HQ	Conc (ug/L)	HQ	Conc (ug/L)	HQ	Conc (ug/L)	HQ	Conc (ug/L)	HQ	Conc (ug/L)	HQ
Arsenic	1.0	290	3E+02	90	9E+01	398	4E+02	27	3E+01	787	8E+02	0.2	2E-01	268	3E+02	852	9E+02	86	9E+01	273	3E+02
Cadmium	100	0.23	2E-03	0.19	2E-03	0.10	1E-03	0.10	1E-03	0.20	2E-03	0.10	1E-03	0.50	5E-03	0.50	5E-03	0.50	5E-03	0.50	5E-03
Copper	60	0.7	1E-02	1.1	2E-02	0.7	1E-02	1.0	2E-02	0.9	2E-02	0.7	1E-02	5.2	9E-02	0.5	8E-03	0.5	8E-03	1.0	2E-02
Lead	20	0.2	9E-03	0.2	1E-02	0.2	9E-03	0.4	2E-02	0.1	6E-03	0.2	1E-02	26.0	1E+00	1.0	5E-02	1.0	5E-02	2.0	1E-01
Mercury	5.0	0.0011	2E-04	0.0012	2E-04	0.0095	2E-03	0.0096	2E-03	0.0180	4E-03	0.0106	2E-03	0.0500	1E-02	0.0500	1E-02	0.1640	3E-02	0.1025	2E-02
Nickel	500	12	2E-02	19	4E-02	24	5E-02	14	3E-02	6	1E-02	2	3E-03	2	3E-03	7	1E-02	7	1E-02	3	6E-03
Selenium	700	0.5	7E-04	0.6	9E-04	0.5	7E-04	0.9	1E-03	0.5	7E-04	1.0	1E-03	3.1	4E-03	1.5	2E-03	2.2	3E-03	1.5	2E-03
Zinc	400	13	3E-02	14	3E-02	11	3E-02	14	3E-02	10	2E-02	7	2E-02	6	1E-02	6	1E-02	6	1E-02	8	2E-02

**Table 7-4**  
**Toxicity Benchmarks for Soil Invertebrates**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

Analyte	ORNL <sup>1</sup>		CCME <sup>2</sup>	RIVM <sup>3</sup>	Geomean of all values (mg/kg dw)
	Earthworm	Micro-organism			
<b>Aluminum</b>	NA	600	NA	NA	600
<b>Antimony</b>	NA	NA	NA	NA	NA
<b>Arsenic</b>	60	100	20	34	45
<b>Barium</b>	NA	3000	NA	NA	3000
<b>Boron</b>	NA	20	NA	NA	20
<b>Chromium</b>	0.4	10	1.8	100	5.2
<b>Copper</b>	50	100	150	40	74
<b>Iron</b>	NA	200	NA	NA	200
<b>Lead</b>	500	900	375	140	392
<b>Manganese</b>	NA	100	NA	NA	100
<b>Mercury</b>	0.1	30	0.8	0.67	1.1
<b>Molybdenum</b>	NA	200	NA	NA	200
<b>Nickel</b>	200	90	150	38	101
<b>Silver</b>	NA	50	NA	NA	50
<b>Thallium</b>	NA	NA	NA	NA	NA
<b>Vanadium</b>	NA	20	55	NA	33
<b>Zinc</b>	100	200	600	160	209

All units are mg/kg dry weight.

NA = Not Available

Source:

1 Oak Ridge National Laboratory (ORNL). Efroymson et al., 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision.

2 Canadian Council of Ministries of the Environment (CCME). 1997. Recommended Canadian Soil Quality Guidelines. March 1997.

3 National Institute of Public Health and the Environment (Bilthoven, The Netherlands) (RIVM). 1997. Maximum Permissible Concentrations and Negligible Concentrations for Metals, taking into account background concentrations. October 1997.

**Table 7-5 Results of Soil Toxicity Tests with the Turnip Seed**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

Exposure	Toxicity Parameter	Laboratory Control	WWC-05	WWC-06	WWC-07	WWC-08	WWC-09	WWC-R-01 M	BFR-R-10	SPC-R-12
7-day	Mean Emergence, %	93.3	0*	0*	0*	93.3*	0*	100.0	0*	0*
	Mean Change, %	100.0	0*	0*	0*	76.7	0*	100.0	0*	0*
28-day	Mean Survival, %	93.3 <sup>a</sup> /86.7 <sup>b</sup>	0*	0*	0*	70.0	0*	100.0	0*	0*
	Mean Height, mm	186.0	NA	NA	NA	37*	NA	146*	NA	NA
	Mean Biomass, mg	82.1	NA	NA	NA	7.20*	NA	39.69*	NA	NA
Soil Concentration (mg/kg)	Aluminum		3220	4410	6710	5990	7890	1800	9540	4270
	Antimony		2.5	3.9	0.74 U	1.2	0.79 U	92.1	0.81 U	0.77 U
	Arsenic		1100	1200	1400	1200	2610	948	13.4	29.9
	Barium		89.6	123	137	143	146	857	171	118
	Beryllium		0.7	1	0.81	0.71	0.68	1	1	0.65
	Boron		3.6	9	6.8	5	6.1	11.2	15.4	9.2
	Cadmium		1.1	0.97	0.96	1.1	1.3	0.88	1.4	0.37
	Calcium		10700	10400	19000	19000	5350	14700	32400	121000
	Chromium		10	10.1	12.1	11.6	12.6	7.8	12.3	7.9
	Cobalt		9.1	11.4	11.5	10.4	12.5	16.5	9.2	3.8
	Copper		35.8	42	45.1	42.1	53.6	78.9	25.9	10.8
	Cyanide		0.6 U	0.82	0.6 U	0.64 U	0.52 U	1 U	0.52 U	0.6 U
	Iron		38700	54000	54100	52300	82800	29400	20000	8350
	Lead		18.9	19.9	18.3	31.1	17.4	42.6	15.7	26.9
	Magnesium		4170	4220	6820	7290	5960	1490	4360	20900
	Manganese		587	714	998	953	1270	1260	639	341
	Mercury		0.26	0.22	0.34	0.31	0.97	4	0.06 U	0.18
	Molybdenum		2.2	6.9	1.8	1.9	1.3	5	3.4	0.76
	Nickel		17.9	21.2	21.7	19.5	18.7	13.8	27.9	7.8
	Potassium		1010	1050	1780	1620	2640	710	2420	1510
	Selenium		1	1.3	1.6	1.5	2.9	1.1	1.9	0.39 U
	Silver		0.45	0.32	0.16	0.18	0.51	7.4	0.14 U	0.13 U
	Sodium		25 U	27.6	26.2 U	24.4 U	28 U	76 U	28.8 U	70.2
	Thallium		0.7 U	0.68 U	0.74 U	0.69 U	0.79 U	5.4	0.81 U	0.77 U
	Vanadium		20.2	28.7	26.8	25.7	27.9	124	38	16.3
	Zinc		82.5	74.9	70.9	63.7	64.5	309	85.6	40.8

\* Statistically significantly different from laboratory control and reference locations ( $\alpha=0.05$ )

a - Value for test run with samples WWC-05, WWC-06, WWC-08, and WWC-13.

b - Value for test run with samples WWC-07, WWC-09, BFR-R-10, and SPC-R-12.

NA = Not available due to mortality

**Table 7-6 Results of Soil Toxicity Tests with Ryegrass**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

Exposure	Toxicity Parameter	Laboratory Control	WWC-R-01	WWC-05	WWC-06	WWC-08	SPC-R-12
approx. 7-day	Initial Soil pH	6.3	7.6	7.7	6.3	7.2	8.6
	Exposure (days) Until Complete Emergence	8.0	7.0	6.0	6.0	6.0	5.0
	Mean Emergence, %	100.0	95.2	100.0	100.0	100.0	100.0
28-day	Mean Shoot Length, mm (SE)	143.3 (7.9)	99.5* (11.2)	145.1 (6.7)	123.7 (9.0)	92.7* (5.7)	206.7 (10.4)
	Mean Dry Shoot Biomass, mg (SE)	41.49 (2.06)	21.39 (9.56)	51.94 (1.72)	41.46 (4.40)	15.82 (2.21)	135.17 (14.44)
	Mean Dry Root Biomass, mg (SE)	47.11 (0.13)	61.43 (0.16)	957.64 (0.26)	240.44 (0.22)	160.37 (0.15)	424.59 (0.12)
Soil Concentration (mg/kg)	Aluminum		6300	3,900	7,600	6,000	2700
	Antimony		7.7 U	6 U	9	7	6.9
	Arsenic		0.3 U	1,800	3,900	960	0.4 U
	Barium		130	130	120	120	99
	Beryllium		0.5	0.3	0.4	0.3	0.2
	Boron		4	7	6	8	7
	Cadmium		1.3 U	0.6 U	2	2	2.1 U
	Calcium		5800	12,000	5,100	16,000	110000
	Chromium		8	10	12	10	5
	Cobalt		3	12	5	10	3
	Copper		9	44	85	30	5
	Cyanide		na	na	na	na	na
	Iron		7500	46,000	85,000	45,000	5000
	Lead		10	28	20	10	20
	Magnesium		2300	5,500	3,900	5,900	19000
	Manganese		140	980	470	920	250
	Mercury		0.01 U	0.30	0.20	0.01	2
	Molybdenum		0.9 U	2	0.8 U	1.0	0.8 U
	Nickel		9	22	7	16	7
	Potassium		890	1100	2600	1000	620
	Selenium		2.6 U	2.2 U	5	2.4	2.3
	Silver		0.6 U	1.0	1.0	0.7	0.6
	Sodium		26 U	110	98	24	110
	Thallium		0.5 U	0.8	0.8	0.8	0.5
	Vanadium		13	25	21	21	11
	Zinc		40	73	53	57	32

\* Statistically significantly different from laboratory control ( $\alpha=0.05$ )

na = Not available

Note: Mean values for biomass are based on plants from each replicate being composited, with the mean value resulting from the three replicates (i.e., individual plants were not weighed).

**Table 7-7 Correlation Between COPCs in Soil and Toxicity to Ryegrass**

*Ecological Risk Assessment for the Whitewood Creek Site*

COPC	Exposure (days) Until Complete Emergence		Mean Emergence, %		Mean Shoot Length, mm		Mean Dry Shoot Biomass, mg		Mean Dry Root Biomass, mg	
	p value	R	p value	R	p value	R	p value	R	p value	R
Aluminum	0.24	0.65	0.64	-0.28	0.10	-0.81	0.12	-0.78	0.27	-0.61
Antimony	0.68	0.26	0.79	-0.16	0.54	-0.37	0.62	-0.30	0.17	-0.72
Arsenic	1.00	0.00	0.44	0.46	0.76	-0.19	0.66	-0.27	0.80	0.16
Barium	0.06	0.87	0.45	-0.45	0.14	-0.76	0.07	-0.84	0.88	0.09
Beryllium	<b>0.02</b>	<b>0.93</b>	0.12	-0.78	0.17	-0.72	0.17	-0.72	0.40	-0.49
Boron	0.19	-0.70	0.05	0.88	0.68	0.26	0.70	0.24	0.52	0.39
Cadmium	0.55	-0.36	0.59	0.33	0.95	-0.04	0.90	0.08	0.23	-0.66
Calcium	0.09	-0.82	0.63	0.30	0.05	0.88	0.02	0.94	0.85	0.12
Chromium	0.50	0.40	0.73	0.21	0.23	-0.65	0.16	-0.73	0.97	0.02
Cobalt	1.00	0.00	0.41	0.48	0.67	-0.26	0.54	-0.37	0.28	0.61
Copper	0.94	0.04	0.46	0.44	0.68	-0.25	0.59	-0.33	0.83	0.14
Iron	0.97	0.03	0.38	0.51	0.58	-0.34	0.50	-0.40	0.87	0.10
Lead	0.43	-0.46	0.33	0.55	0.29	0.60	0.43	0.46	0.03	0.91
Magnesium	0.05	-0.88	0.48	0.42	0.04	0.89	0.02	0.94	0.75	0.20
Manganese	0.87	-0.10	0.28	0.60	0.69	-0.25	0.58	-0.34	0.34	0.54
Mercury	0.08	-0.83	0.59	0.33	0.01	0.95	0.00	0.99	0.73	0.21
Molybdenum	0.91	0.07	0.72	0.22	0.97	0.02	0.84	-0.12	0.05	0.88
Nickel	0.86	0.11	0.66	0.27	0.73	-0.22	0.59	-0.33	0.21	0.68
Potassium	0.84	0.12	0.68	0.25	0.66	-0.27	0.61	-0.31	0.85	-0.12
Selenium	0.89	0.09	0.82	0.14	0.76	-0.19	0.75	-0.20	0.61	-0.31
Silver	1.00	0.00	0.40	0.49	0.89	-0.09	0.72	-0.23	0.33	0.56
Sodium	0.22	-0.67	0.29	0.60	0.11	0.79	0.19	0.70	0.18	0.71
Thallium	1.00	0.00	0.27	0.61	0.52	-0.39	0.42	-0.48	0.60	0.32
Vanadium	0.85	0.12	0.40	0.49	0.53	-0.38	0.39	-0.50	0.39	0.51
Zinc	0.77	0.18	0.52	0.39	0.56	-0.35	0.41	-0.49	0.27	0.61

p value < 0.05 & significant R

**Table 7-8 Results of Soil Toxicity Tests with the Earthworm**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

Exposure	Toxicity Parameter	Laboratory Control	WWC-05	WWC-06	WWC-07	WWC-08	WWC-09	WWC-R-01 M	BFR-R-10 (Ref)	SPC-R-12 (Ref)
14-day	Mean Survival, % (SE)	99.5 (0.5)	0.0 (0.0)*	89.5 (5.3)	87.6 (9.6)	94.3 (4.4)	99.1 (0.5)	99.1 (0.5)	98.6 (0.8)	98.1 (1.0)
	Mean Length, mm (SE)	50.4 (1.2)	NA	47.1 (2.7)	47.2 (2.2)	48.3 (2.1)	48.2 (2.9)	44.1 (1.6)	46.6 (0.8)	52.8 (0.4)
	Mean Weight Change, % (SE)	-5.0 (5.5)	NA	-5.0 (7.1)	-4.2 (10.1)	-17.5 (3.6)	-15.8 (0.1)	-10.1 (4.9)	-21.1 (2.6)	-9.7 (0.4)
28-day	Mean Survival, % (SE)	94.3 (2.2)	0.0 (0.0)*	89.1 (5.5)	90.5 (6.9)	95.2 (1.9)	98.6 (1.4)	92.4 (6.2)	90.5 (4.7)	99.1 (0.5)
	Mean Length, mm (SE)	36.5 (2.0)	NA	38.0 (0.3)	37.3 (0.8)	37.8 (0.8)	35.5 (1.8)	38.7 (2.2)	36.4 (1.3)	35.4 (0.7)
	Mean Weight Change, % (SE)	-34.5 (1.9)	NA	-24.6 (4.5)	-31.0 (3.3)	-30.7 (1.2)	-32.9 (1.2)	-25.7 (3.2)	-30.5 (4.0)	-28.7 (1.0)
Soil Concentration (mg/kg)	Aluminum		3,220	4,410	6,710	5,990	7,890	1800	9540	4270
	Antimony		2.5	3.9	0.74 U	1.2	0.79 U	92.1	0.81 U	0.77 U
	Arsenic		1,100	1,200	1,400	1,200	2,610	948	13.4	29.9
	Barium		90	123	137	143	146	857	171	118
	Beryllium		0.7	1.0	0.8	0.7	0.7	1.0	1.0	0.65
	Boron		3.6	9.0	6.8	5.0	6.1	11.2	15.4	9.2
	Cadmium		1.1	1.0	1.0	1.1	1.3	0.88	1.4	0.37
	Calcium		10,700	10,400	19,000	19,000	5,350	14700	32400	121000
	Chromium		10	10	12	12	13	7.8	12.3	7.9
	Cobalt		9.1	11	12	10	13	16.5	9.2	3.8
	Copper		36	42	45	42	54	78.9	25.9	10.8
	Cyanide		0.6 U	0.8	0.6 U	0.64 U	0.52 U	1 U	0.52 U	0.6 U
	Iron		38,700	54,000	54,100	52,300	82,800	29400	20000	8350
	Lead		19	20	18	31	17	42.6	15.7	26.9
	Magnesium		4,170	4,220	6,820	7,290	5,960	1490	4360	20900
	Manganese		587	714	998	953	1,270	1260	639	341
	Mercury		0.26	0.22	0.34	0.31	1.0	4.0	0.06 U	0.18
	Molybdenum		2.2	6.9	1.8	1.9	1.3	5.0	3.4	0.76
	Nickel		17.9	21.2	21.7	19.5	18.7	13.8	27.9	7.8
	Potassium		1010	1050	1780	1620	2640	710	2420	1510
	Selenium		1.0	1.3	1.6	1.5	2.9	1.1	1.9	0.39 U
	Silver		0.45	0.32	0.16	0.18	0.51	7.4	0.14 U	0.13 U
	Sodium		25 U	27.6	26.2 U	24.4 U	28 U	76 U	28.8 U	70.2
	Thallium		0.7 U	0.68 U	0.74 U	0.69 U	0.79 U	5.4	0.81 U	0.77 U
	Vanadium		20.2	28.7	26.8	25.7	27.9	124	38	16.3
	Zinc		82.5	74.9	70.9	63.7	64.5	309	85.6	40.8

\* Statistically significantly different from laboratory control and reference locations ( $\alpha=0.05$ )

NA = Not available due to mortality

**Table 7-9 Correlation Between COPCs in Soil and Toxicity to Earthworms**

*Ecological Risk Assessment for the Whitewood Creek Site*

COPC	14d - Mean Survival, %		14d - Mean Length, mm		14d - Mean Weight Change, %		28d - Mean Survival, %		28d - Mean Length, mm		28d - Mean Weight Change, %	
	p value	R	p value	R	p value	R	p value	R	p value	R	p value	R
Aluminum	0.38	0.36	0.83	0.10	0.18	-0.58	0.39	0.35	0.21	-0.54	<b>0.04</b>	<b>-0.77</b>
Antimony	0.68	0.17	0.14	-0.62	0.77	0.14	0.79	0.11	0.16	0.60	0.22	0.53
Arsenic	0.92	-0.04	0.63	-0.22	0.81	0.11	1.00	0.00	0.97	0.02	0.46	-0.34
Barium	0.54	0.26	0.12	-0.64	0.87	0.08	0.65	0.19	0.18	0.58	0.28	0.47
Beryllium	0.49	0.29	<b>0.04</b>	<b>-0.77</b>	0.83	0.10	0.61	0.21	0.14	0.62	0.13	0.63
Boron	0.17	0.54	0.51	-0.30	0.55	-0.28	0.25	0.46	1.00	0.00	0.49	0.32
Cadmium	0.80	-0.11	0.19	-0.56	0.17	-0.58	0.72	-0.15	0.90	0.06	0.34	-0.43
Calcium	0.59	0.23	0.03	0.81	0.90	0.06	0.55	0.25	0.21	-0.54	0.94	0.04
Chromium	0.85	0.08	0.77	-0.14	0.37	-0.40	0.82	0.10	0.61	-0.23	0.06	-0.73
Cobalt	0.71	0.16	<b>0.01</b>	<b>-0.90</b>	0.83	0.10	0.78	0.12	0.10	0.67	0.66	0.21
Copper	0.77	0.12	<b>0.03</b>	<b>-0.80</b>	0.75	0.15	0.82	0.10	0.12	0.65	0.63	0.22
Cyanide	0.73	0.14	0.20	-0.55	0.31	0.45	0.79	0.11	0.03	0.81	0.01	0.86
Iron	0.96	0.02	0.63	-0.22	0.89	0.07	0.87	0.07	0.93	0.04	0.42	-0.36
Lead	0.54	0.26	0.60	-0.24	0.86	0.08	0.58	0.23	0.19	0.56	0.29	0.47
Magnesium	0.63	0.20	0.00	0.95	0.81	0.11	0.54	0.26	0.12	-0.64	0.73	-0.16
Manganese	0.44	0.32	0.10	-0.67	0.94	-0.03	0.45	0.31	0.40	0.38	0.69	-0.19
Mercury	0.61	0.21	0.15	-0.61	0.82	0.11	0.71	0.16	0.24	0.51	0.38	0.40
Molybdenum	0.81	0.10	0.13	-0.63	0.52	0.30	0.90	0.05	0.08	0.70	0.02	0.83
Nickel	0.99	0.00	0.25	-0.50	0.47	-0.33	0.95	-0.03	0.74	0.16	0.58	-0.26
Potassium	0.36	0.37	0.61	0.24	0.15	-0.60	0.36	0.38	0.06	-0.74	<b>0.01</b>	<b>-0.88</b>
Selenium	0.53	0.26	0.48	-0.32	0.33	-0.44	0.54	0.26	0.60	-0.24	0.13	-0.63
Silver	0.70	0.16	0.14	-0.62	0.79	0.12	0.81	0.10	0.18	0.57	0.25	0.50
Sodium	0.45	0.31	0.83	0.10	0.66	0.20	0.50	0.28	0.92	0.05	0.29	0.47
Thallium	0.63	0.20	0.14	-0.61	0.81	0.11	0.74	0.14	0.19	0.56	0.26	0.49
Vanadium	0.54	0.25	0.07	-0.72	0.92	0.05	0.67	0.18	0.15	0.61	0.28	0.48
Zinc	0.78	0.12	0.07	-0.72	0.85	0.09	0.91	0.05	0.13	0.63	0.25	0.50

**Table 7-10**  
**Results of the Terrestrial Habitat Evaluation**

*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*

Family	Genus	Species	Common Name	WWC-R-01	WWC-05	WWC-06	WWC-08	SPC-R-12
<b>Salicaceae</b>	<i>Populus</i>	<i>sargentii</i>	Plains cottonwood		X			
	<i>Populus</i>	sp.	Cottonwood				X	X
	<i>Salix</i>	sp.	Willow		X	X	X	X
	<i>Populus</i>	<i>tremuloides</i>	Quaking aspen	X				
<b>Pinaceae</b>	<i>Pinus</i>	<i>ponderosa</i>	Ponderosa pine	X				
	<i>Picea</i>	sp.	Spruce	X				
	<i>Pseudotsuga</i>	<i>menziesii</i>	Douglas fir	X				
<b>Fagaceae</b>	<i>Quercus</i>	<i>macrocarpa</i>	Bur oak		X			
	<i>Fagus</i>	sp.	Beech		X		X	
<b>Elaeagnaceae</b>	<i>Elaeagnus</i>	<i>angustifolia</i>	Russian olive		X	X	X	X
<b>Cupressaceae</b>	<i>Juniperus</i>	sp.	Juniper	X				
<b>Cornaceae</b>	<i>Cornus</i>	sp.	Dogwood		X			
<b>Asteraceae</b>	<i>Helianthus</i>	sp.	Sunflower	X			X	
	<i>Aster</i>	<i>ericoides</i>	White aster	X			X	
	<i>Tanacetum</i>	<i>vulgare</i>	Common tansy	X	X	X		X
	<i>Solidago</i>	spp.	Goldenrod	X	X	X		X
	<i>Cirsium</i>	<i>vulgare</i>	Bull thistle	X	X	X		X
	<i>Chrysanthemum</i>	sp.	Daisy	X	X			
	<i>Chrysopsis</i>	<i>villosa</i>	Golden aster		X			
	<i>Rudbeckia</i>	<i>herta</i>	Black-eyed susan	X				
	<i>Achillea</i>	<i>millefolium</i>	Yarrow	X				
	<i>Erigeron</i>	<i>strigosus</i>	Daisy fleabane	X				
	<i>Antennaria</i>	sp.	Pussy-toes	X				
<b>Fabaceae</b>	<i>Melilotus</i>	<i>officinalis</i>	Yellow sweet clover		X		X	X
	<i>Melilotus</i>	<i>alba</i>	White sweet clover		X			X
	<i>Trifolium</i>	<i>pratense</i>	Red clover	X				X
	<i>Dalea</i>	<i>purpurea</i>	Purple prairie clover				X	
	<i>Lespedeza</i>	sp.	Lespedeza					X
<b>Lamiaceae</b>	<i>Monarda</i>	<i>fistulosa</i>	Wild bergamot					X
	<i>Mentha</i>	<i>spicata</i>	Spearmint			X		
	<i>Salvia</i>	sp.	Sage	X				
<b>Caryophyllaceae</b>	<i>Saponaria</i>	<i>officinalis</i>	Bouncing bet		X			X
	<i>Silene</i>	<i>pratensis</i>	White campion					X
<b>Polygonaceae</b>	<i>Rumex</i>	<i>crispus</i>	Curly dock	X	X	X		
	<i>Polygonum</i>	sp.	Smartweed		X	X		
<b>Rosaceae</b>	<i>Rubus</i>	sp.	Raspberry	X				
	<i>Potentilla</i>	sp.	Cinquefoil	X				
	<i>Rosa</i>	sp.	Rose	X				
<b>Apiaceae</b>	<i>Daucus</i>	<i>carota</i>	Queen Anne's lace	X				X
<b>Verbenaceae</b>	<i>Verbena</i>	<i>hastata</i>	Blue vervain		X	X		X
<b>Asclepiadaceae</b>	<i>Asclepias</i>	sp.	Milkweed		X			X
<b>Scrophulariaceae</b>	<i>Verbascum</i>	<i>thapsus</i>	Common mullein	X	X			X
<b>Onagraceae</b>	<i>Oenothera</i>	<i>biennis</i>	Evening primrose		X			
<b>Iridaceae</b>	<i>Iris</i>	sp.	Iris	X				
<b>Boraginaceae</b>	<i>Mertensia</i>	<i>virginica</i>	Bluebells	X				
<b>Grossulariaceae</b>	<i>Ribes</i>	sp.	Gooseberry	X				
<b>Poaceae</b>	<i>Phragmites</i>	sp.	Reed				X	
<b>Graminae</b>			Grasses spp.	X	X	X	X	X
<b>Total # of Species</b>				27	21	10	10	18

**Table 7-11 Results of Soil Microbial Community Analyses**

*Ecological Risk Assessment  
Whitewood Creek , Lead, South Dakota*

Parameter	Location					
	WWC-R-01	SPC-R-12	WWC-05	WWC-06	WWC-08	Expected*
Active Bacterial Biomass (µg/g)	1.5	3.7	9.4	6.1	3.2	3
Total Bacterial Biomass (µg/g)	207	208	110.9	118.6	182	3
Active Fungal Biomass (µg/g)	3	0	30.07	11.94	0.73	150
Total Fungal Biomass (µg/g)	53	260	657.45	131.15	52	350
Ratio of Active Fungal Biomass to Active Bacterial Biomass	2.0	0	3.2	2.0	0.23	2 to 5
Ratio of Total Fungal Biomass to Total Bacterial Biomass	0.26	1.3	5.9	1.1	0.29	
Ratio of Active to Total Bacterial Biomass	0.007	0.02	0.08	0.05	0.02	
Ratio of Active to Total Fungal Biomass	0.06	0.00	0.05	0.09	0.01	
Hyphal Diameter (µm)	2.5	3	2.5	2.5	2.5	
Total Protozoa (#/g) - Flagellates	6,131	3,215	515	36,213	222	10,000
Total Protozoa (#/g) - Amoebae	6,131	6,672	1,553	36,213	3,604	5,000
Total Protozoa (#/g) - Ciliates	377	321	31	526	75	75
Total Nematode Numbers (#/g)	31	28	2	1.1	5.5	38
Percent Mycorrhizal Colonization of Root	70	35	32	75	56	60
Net Ammonia-Nitrogen (µg N/g)	0.75	1.62	0.29	0.84	0	
Net Nitrate-Nitrogen (µg N/g)	0.17	34.17	62.66	65.24	46.96	
Net Nitrogen Mineralization (µg N/g)	-0.58	32.55	62.37	73.64	46.96	
Net DON (µg N/g)	11.5	16.16	80.46	92.6	105.76	
Net MBN (µg N/g)	-78.33	-55.9	25.05	-12.93	56.38	
Net DOC (µg C/g)	61.7	113.5	17.3	47.6	54.2	
Net Dehydrogenase (µg TTF/g/hr) <sup>a</sup>	-1.47	0.01	0.02	-0.18	-0.04	
Net Beta-glucosidase (µg PNP/g/hr) <sup>b</sup>	2.51	-1.11	-2.33	-4.34	-0.18	
Net MBC (µg C/g)	8.7	-14.22	-22.2	179.71	-236.19	
Cumulative Soil Respiration (µg CO <sub>2</sub> -C/g)	1562	1206	623	1736	454	

a TPF = triphenyl formazan

b PNP = p-nitrophenol

DON = Dissolved Organic Nitrogen

DOC = Dissolved Organic Carbon

MBN = Microbial Biomass Nitrogen

MBC = Microbial Biomass Carbon

\* Ordinarily may be expected for this region, as provided by Soil Foodweb, Inc. (Corvallis, OR).

**Table 8-1 Summary of Receptors and Exposure Pathways**

Receptor	Surface/Seep Water	Riparian Soil	Stream Sediment	Terrestrial Vertebrates	Terrestrial Plants	Terrestrial Insects	Aquatic Insects	Soil Invert.	Fish
Masked shrew	x	x						x	
American robin	x	x			x			x	
Deer mouse	x	x			x	x		x	
Meadow vole	x	x			x	x		x	
Cliff swallow	x	x				x			
Belted kingfisher	x		x				x		x
Mink	x		x	x			x		x
Red fox	x	x		x	x				
American kestrel	x	x		x		x			
Great horned owl	x	x		x					x
American Dipper	x		x				x		

**Table 8-2 Summary of Exposure Point Concentrations for Wildlife**

*Ecological Risk Assessment for the Whitewood Creek Site*

Reach	COPC	Surface Water (Total)	Sediment (Total)	Soil - Flood Plain (Total)	Composite Grasses	Sweet Clover	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish
		EPC (mg/L)	EPC (mg/kg)	EPC (mg/kg)	EPC <sup>a</sup> (mg/kg ww)	EPC (mg/kg ww)	EPC (mg/kg ww)	EPC (mg/kg ww)	EPC <sup>b</sup> (mg/kg ww)	EPC (mg/kg ww)	EPC (mg/kg ww)
WWC - Reach A	Aluminum	NC	7980.00	11167	121.90	21.73	278	13	15	291	NA
	Antimony	NC	3.20	3.7	0.12	0.13	0.48	0.53	0.67	0.06	NA
	Arsenic	0.0098	235.00	0.2	0.44	0.13	0.41	0.04	77.00	53.70	NA
	Barium	NC	167.00	310.0	34.45	23.85	8.10	1.72	9.00	16.50	NA
	Beryllium	NC	NC	5.0	0.12	0.13	0.02	0.02	0.11	NA	NA
	Cadmium	NC	1.10	0.7	0.29	0.34	0.08	0.05	0.81	0.11	NA
	Chromium	NC	19.00	13.7	0.29	0.34	2.03	1.05	0.70	0.78	NA
	Copper	NC	43.00	14.0	2.51	5.83	2.96	10.15	4.20	2.83	NA
	Lead	NC	14.80	20	0.48	0.13	0.46	0.06	0.25	0.21	NA
	Manganese	NC	1130.00	490.0	302.10	19.61	9.27	21.70	10.85	675.00	NA
	Mercury	NC	0.19	1	0.07	0.04	0.00	0.01	0.28	NA	NA
	Molybdenum	NC	1.70	0.5	NA	NA	NA	NA	NA	NA	NA
	Thallium	NC	NC	0	0.12	0.13	0.003	0.00	1.05	NA	NA
	Vanadium	NC	28.10	18.1	0.59	0.66	0.26	0.18	1.09	0.90	NA
	Zinc	1.2541	139.00	46	15.88	22.26	32.73	53.90	35.70	50.10	NA
WWC - Reach B	Aluminum	NC	9050.00	NA	NA	NA	NA	NA	NA	142	NA
	Antimony	NC	1.50	NA	NA	NA	NA	NA	NA	0.01	NA
	Arsenic	0.0160	484.00	NA	NA	NA	NA	NA	NA	4.98	NA
	Barium	NC	440.00	NA	NA	NA	NA	NA	NA	2.28	NA
	Beryllium	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA
	Cadmium	NC	1.80	NA	NA	NA	NA	NA	NA	0.01	NA
	Chromium	NC	30.10	NA	NA	NA	NA	NA	NA	0.75	NA
	Copper	NC	93.00	NA	NA	NA	NA	NA	NA	5.58	NA
	Lead	NC	245.00	NA	NA	NA	NA	NA	NA	0.17	NA
	Manganese	NC	1100.00	NA	NA	NA	NA	NA	NA	28.20	NA
	Mercury	NC	0.34	NA	NA	NA	NA	NA	NA	NA	NA
	Molybdenum	NC	3.60	NA	NA	NA	NA	NA	NA	NA	NA
	Thallium	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA
	Vanadium	NC	42.70	NA	NA	NA	NA	NA	NA	0.45	NA
	Zinc	3.4677	216.00	NA	NA	NA	NA	NA	NA	19.05	NA
WWC - Reach C	Aluminum	NC	6840.00	10373	30.44	12.25	38	27	30	156	7.20
	Antimony	NC	2.40	8.5	0.08	0.12	0.48	0.53	0.11	0.01	0.01
	Arsenic	0.0784	1230.00	4106.3	6.35	16.66	3.01	1.33	126.00	22.65	9.70
	Barium	NC	201.00	187.4	7.95	5.09	3.03	0.63	2.17	3.08	0.56
	Beryllium	NC	NC	0.8	0.08	0.12	0.02	0.02	0.11	NA	NA
	Cadmium	NC	1.40	1.3	0.32	0.31	0.07	0.25	1.23	0.02	0.01
	Chromium	NC	17.20	16.8	0.29	0.31	1.81	4.90	0.91	0.82	0.84
	Copper	NC	109.00	83.5	2.97	5.57	3.88	13.30	4.55	3.90	1.46
	Lead	NC	44.80	35	0.13	0.17	0.10	0.02	0.11	0.37	0.67
	Manganese	NC	902.00	1456.0	52.18	20.43	4.83	4.62	9.80	28.19	2.64
	Mercury	NC	0.65	2	0.03	0.03	0.04	0.00	0.10	0.03	0.14
	Molybdenum	NC	3.00	3.1	NA	NA	NA	NA	NA	NA	NA
	Thallium	NC	NC	1	0.08	0.12	0.004	0.00	0.11	NA	NA
	Vanadium	NC	31.70	33.4	0.40	0.59	0.15	0.05	0.28	0.62	0.17
	Zinc	0.0795	133.00	98	14.56	19.41	38.48	47.25	35.70	22.80	51.60
WWC - Reach D	Aluminum	NC	10142.40	10211	26.50	13.78	107	11	112	183	37.44
	Antimony	NC	0.48	10.0	0.07	0.14	0.48	0.53	0.11	0.02	0.01
	Arsenic	0.1277	805.39	2884.4	2.28	1.17	2.56	5.18	162.05	17.70	3.20
	Barium	NC	191.00	161.8	17.49	2.49	3.01	0.67	2.70	3.84	1.38
	Beryllium	NC	NC	0.8	0.07	0.14	0.02	0.02	0.11	NA	NA
	Cadmium	NC	1.30	1.8	0.17	0.34	0.10	0.14	1.44	0.02	0.03
	Chromium	NC	17.60	15.0	0.58	0.34	1.92	1.40	1.16	0.80	0.86
	Copper	NC	36.60	55.1	2.41	4.88	4.80	11.55	3.96	3.45	0.86
	Lead	NC	16.78	21	0.07	0.14	0.14	0.01	0.26	0.23	0.03
	Manganese	NC	845.00	1553.4	201.40	16.96	4.03	5.04	28.95	133.65	42.24
	Mercury	NC	0.31	1	0.02	0.03	0.03	0.00	0.12	0.05	0.13
	Molybdenum	NC	2.05	1.9	NA	NA	NA	NA	NA	NA	NA
	Thallium	NC	NC	1	0.07	0.14	0.003	0.00	0.11	NA	NA
	Vanadium	NC	49.70	30.7	0.33	0.69	0.19	0.18	0.53	0.84	0.36
	Zinc	0.2628	94.30	73	13.43	14.84	48.64	51.10	37.45	18.60	36.43

**Table 8-2 Summary of Exposure Point Concentrations for Wildlife**

*Ecological Risk Assessment for the Whitewood Creek Site*

Reach	COPC	Surface Water (Total)	Sediment (Total)	Soil - Flood Plain (Total)	Composite Grasses	Sweet Clover	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish
		EPC (mg/L)	EPC (mg/kg)	EPC (mg/kg)	EPC <sup>a</sup> (mg/kg ww)	EPC (mg/kg ww)	EPC (mg/kg ww)	EPC (mg/kg ww)	EPC <sup>b</sup> (mg/kg ww)	EPC (mg/kg ww)	EPC (mg/kg ww)
<b>BFR - Reach A</b>	Aluminum	NC	5640.00	9540	NA	NA	NA	NA	NA	NA	189.36
	Antimony	NC	0.49	0.4	NA	NA	NA	NA	NA	NA	0.01
	Arsenic	0.0059	13.50	13.4	NA	NA	NA	NA	NA	NA	0.58
	Barium	NC	254.00	171.0	NA	NA	NA	NA	NA	NA	3.10
	Beryllium	NC	NC	1.0	NA	NA	NA	NA	NA	NA	NA
	Cadmium	NC	1.90	1.4	NA	NA	NA	NA	NA	NA	0.02
	Chromium	NC	9.40	12.3	NA	NA	NA	NA	NA	NA	1.08
	Copper	NC	20.60	25.9	NA	NA	NA	NA	NA	NA	0.89
	Lead	NC	11.80	16	NA	NA	NA	NA	NA	NA	0.10
	Manganese	NC	623.00	639.0	NA	NA	NA	NA	NA	NA	10.56
	Mercury	NC	0.04	0	NA	NA	NA	NA	NA	NA	0.12
	Molybdenum	NC	4.60	3.4	NA	NA	NA	NA	NA	NA	NA
	Thallium	NC	NC	0	NA	NA	NA	NA	NA	NA	NA
	Vanadium	NC	46.20	38.0	NA	NA	NA	NA	NA	NA	0.74
	Zinc	0.0055	78.10	86	NA	NA	NA	NA	NA	NA	46.90
<b>BFR - Reach B</b>	Aluminum	NC	6990.00	NA	NA	NA	NA	NA	NA	100	113.76
	Antimony	NC	0.55	NA	NA	NA	NA	NA	NA	0.02	0.01
	Arsenic	0.0020	1400.00	NA	NA	NA	NA	NA	NA	1.31	1.90
	Barium	NC	183.00	NA	NA	NA	NA	NA	NA	2.04	1.62
	Beryllium	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA
	Cadmium	NC	1.30	NA	NA	NA	NA	NA	NA	0.01	0.02
	Chromium	NC	11.60	NA	NA	NA	NA	NA	NA	0.68	1.03
	Copper	NC	31.10	NA	NA	NA	NA	NA	NA	2.72	1.13
	Lead	NC	20.30	NA	NA	NA	NA	NA	NA	0.13	0.06
	Manganese	NC	844.00	NA	NA	NA	NA	NA	NA	123.00	17.28
	Mercury	NC	0.17	NA	NA	NA	NA	NA	NA	NA	0.17
	Molybdenum	NC	2.20	NA	NA	NA	NA	NA	NA	NA	NA
	Thallium	NC	NC	NA	NA	NA	NA	NA	NA	NA	NA
	Vanadium	NC	39.70	NA	NA	NA	NA	NA	NA	0.54	0.53
	Zinc	0.0055	76.80	NA	NA	NA	NA	NA	NA	15.30	73.30
<b>SPC</b>	Aluminum	NC	3140.00	3631	53.00	11.07	64.32	6	NA	72	21.36
	Antimony	NC	0.49	6.9	0.08	0.12	0.48	0.53	NA	0.00	0.01
	Arsenic	0.0020	13.50	29.9	0.36	0.12	0.29	0.11	NA	0.47	0.23
	Barium	NC	133.00	120.0	17.49	15.59	4.85	0.77	NA	2.66	0.97
	Beryllium	NC	NC	0.7	0.08	0.12	0.02	0.02	NA	NA	NA
	Cadmium	NC	0.37	2.1	0.19	0.32	0.07	0.14	NA	0.00	0.01
	Chromium	NC	6.30	6.8	0.33	0.32	1.67	0.35	NA	0.69	3.50
	Copper	NC	6.80	8.5	2.70	4.35	3.78	9.10	NA	1.41	0.72
	Lead	NC	13.80	26	0.52	0.12	1.08	0.01	NA	0.21	0.05
	Manganese	NC	194.00	307.7	23.61	14.12	5.28	2.31	NA	10.05	1.92
	Mercury	NC	0.04	2	0.02	0.03	0.10	0.00	NA	0.02	0.11
	Molybdenum	NC	0.08	0.8	NA	NA	NA	NA	NA	NA	NA
	Thallium	NC	NC	1	0.08	0.12	0.004	0.00	NA	NA	NA
	Vanadium	NC	10.60	14.4	0.39	0.63	0.24	0.05	NA	0.39	0.31
	Zinc	0.0055	25.20	36	13.78	18.29	45.43	44.45	NA	16.20	52.56

a Based on unwashed concentrations.

b Based on 28 day bioaccumulation concentrations.

**Table 8-3**  
**Exposure Factors for Representative Wildlife Species**

*Ecological Risk Assessment for the Whitewood Creek Site, Lead, South Dakota*

Class	Type	Receptor	Genus species	Body Weight (kg wet weight)	Food Ingestion Rate (kg wet weight/day)	Water Ingestion Rate (L/day)	Sediment Ingestion Rate (kg dry weight/day)	Soil Ingestion Rate (kg dry weight/day)	Home Range Size (ha)
Avian	Terrestrial Insectivore	Cliff Swallow	<i>Petrochelidon pyrchonota</i>	0.02105	0.005	0.004	NA	0.00007	No Info
	Terrestrial Carnivore	Great Horned Owl	<i>Bubo virginianus</i>	1.62325	0.082	0.082	NA	0.00033	No Info
	Aquatic Insectivore	American Dipper	<i>Cinclus mexicanus</i>	0.0578	0.009	0.009	0.00004	NA	No Info
	Aquatic Piscivore	Belted Kingfisher	<i>Ceryle alcyon</i>	0.147	0.0735	0.016	0.0004	NA	No Info
	Terrestrial Omnivore	American Robin	<i>Turdus migratorius</i>	0.081	0.078	0.011	NA	0.0012	0.48
	Terrestrial Carnivore	American Kestrel	<i>Falco sparverius</i>	0.115	0.033	0.014	NA	0.0001	167
Mammalian	Terrestrial Omnivore	Meadow Vole	<i>Microtis pennsylvanicus</i>	0.033	0.010	0.005	NA	0.0004	0.027
	Terrestrial Carnivore	Red Fox	<i>Vulpes vulpes</i>	4.54	0.310	0.386	NA	0.0023	1,038
	Terrestrial Insectivore	Masked Shrew	<i>Sorex cinereus</i>	0.0053	0.009	0.001	NA	0.0004	0.39
	Semi-Aquatic Piscivore	Mink	<i>Mustela vison</i>	0.556	0.089	0.058	0.0002	NA	14.1
	Terrestrial Herbivore	Deer Mouse	<i>Peromyscus maniculatus</i>	0.02	0.005	0.00	NA	0.00006	0.065

NA = Not applicable

**Table 8-4**  
**Dietary Fractions for Representative Wildlife Species**

*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*

Class	Type	Receptor	Genus species	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Aquatic Invertebrates	Fish
Avian	Terrestrial Insectivore	Cliff Swallow	<i>Petrochelidon pyrchonota</i>	NA	NA	100%	NA	NA	NA
	Terrestrial Carnivore	Great Horned Owl	<i>Bubo virginianus</i>	NA	95%	NA	NA	NA	5%
	Aquatic Insectivore	American Dipper	<i>Cinclus mexicanus</i>	NA	NA	NA	NA	100%	NA
	Aquatic Piscivore	Belted Kingfisher	<i>Ceryle alcyon</i>	NA	NA	NA	NA	10%	90%
	Terrestrial Omnivore	American Robin	<i>Turdus migratorius</i>	23%	NA	NA	77%	NA	NA
	Terrestrial Carnivore	American Kestrel	<i>Falco sparverius</i>	NA	67%	33%	NA	NA	NA
Mammalian	Terrestrial Omnivore	Meadow Vole	<i>Microtis pennsylvanicus</i>	90%	NA	5%	5%	NA	NA
	Terrestrial Carnivore	Red Fox	<i>Vulpes vulpes</i>	10%	90%	NA	NA	NA	NA
	Terrestrial Insectivore	Masked Shrew	<i>Sorex cinereus</i>	NA	NA	50%	50%	NA	NA
	Semi-Aquatic Piscivore	Mink	<i>Mustela vison</i>	NA	20%	NA	NA	20%	60%
	Terrestrial Herbivore	Deer Mouse	<i>Peromyscus maniculatus</i>	90%	NA	5%	5%	NA	NA

NA = Not applicable

All dietary fractions are expressed as percent wet weight

**Table 8-5 Uncertainty Factors Used in Deriving Terrestrial TRVs**

***Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota***

Category	Basis for Uncertainty	Description	Uncertainty Factor
A	Inter-taxon Extrapolation	Same species	1
		Same genus, different species	2
		Same family, different genus	3
		Same order, different family	4
		Same class, different order	5
		Same phylum, different class	Do not use
B	Exposure Duration	Chronic study, approximately steady-state	1
		Subchronic studies, steady state not achieved	3
		Subacute studies (4-9 days for aquatic, 7-29 days for terrestrial)	5
		Acute studies (1-3 days for aquatic, 1-6 days for terrestrial)	10
		Peracute studies (less than 1 day, single dose)	15
C	Toxicological Endpoint	NOEL for non-lethal sensitive endpoint	0.75 to 1
		NOEL for lethality or severe endpoint	2
		NOAEL for non-lethal sensitive endpoint	1 to 2
		NOAEL for lethality or severe endpoint	3
		LOEL for non-lethal sensitive endpoint	2 to 3
		LOEL for lethality or severe endpoint	5
		LOAEL for non-lethal sensitive endpoint	3 to 5
		LOAEL for lethality or severe endpoint	10
		FEL for non-lethal sensitive endpoint	5 to 10
		FEL for lethality or severe endpoint	15
D	Modifying Factors	Endangered species	2
		Threatened species	1.5
		Listed species	1.25
		Relevance of toxicological endpoint to assessment endpoints	1 to 2
		Extrapolation from test conditions to site conditions	0.5 to 2
		Relevance of exposure medium and co-contaminants	0.5 to 2
		Relevance of mechanism to receptor of concern	1 to 2
		Sensitivity of test species compared to receptor of concern	0.5 to 2
		Reliability of methods used to estimate tissue levels	1 to 2
		Differences in age, gender, development	1 to 2
		Other factors	0.5 to 2

TRV = Study Dose / Total UF

Total UF = A · B · C · D, where A = a<sub>1</sub>·a<sub>2</sub>·a<sub>3</sub>· ..... ·a<sub>n</sub>

**Table 8-6 Summary of Toxicity Reference Values (TRVs) for Wildlife Receptors**  
**Ecological Risk Assessment for the Whitewood Creek Site, Lead, South Dakota**

Chemical	TRV	Deer Mouse		Mink		Meadow Vole		Masked Shrew		Red Fox		American Robin		Cliff Swallow		American Kestrel		Belted Kingfisher		American Dipper		Great Horned Owl	
		water	diet	water	diet	water	diet	water	diet	water	diet	water	diet	water	diet	water	diet	water	diet	water	diet	water	diet
Aluminum	NOAEL	1.133	2.267	1.133	2.267	1.133	2.267	1.133	2.267	1.133	2.267	3.500	7.000	3.500	7.000	3.500	7.000	3.500	7.000	3.500	7.000	3.500	7.000
	LOAEL	5.507	11.013	5.507	11.013	5.507	11.013	5.507	11.013	5.507	11.013	17.500	35.000	17.500	35.000	17.500	35.000	17.500	35.000	17.500	35.000	17.500	35.000
Antimony	NOAEL	0.013	0.025	0.003	0.006	0.003	0.006	0.003	0.006	0.013	0.025	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	LOAEL	0.038	0.075	0.009	0.019	0.009	0.019	0.009	0.019	0.038	0.075	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	NOAEL	1.265	2.530	0.253	0.150	0.422	0.120	0.253	0.120	0.253	0.200	0.407	0.814	0.407	0.814	0.407	0.814	0.407	0.814	0.407	0.814	0.407	0.814
	LOAEL	3.795	7.590	0.759	0.450	1.265	0.360	0.759	0.360	0.759	0.600	3.526	7.053	3.526	7.053	3.526	7.053	3.526	7.053	3.526	7.053	3.526	7.053
Barium	NOAEL	1.686	3.372	1.011	2.023	1.686	3.372	1.011	2.023	1.011	2.023	1.388	2.777	1.388	2.777	1.388	2.777	1.388	2.777	1.388	2.777	1.388	2.777
	LOAEL	5.057	10.115	3.034	6.069	5.057	10.115	3.034	6.069	3.034	6.069	2.777	5.554	2.777	5.554	2.777	5.554	2.777	5.554	2.777	5.554	2.777	5.554
Beryllium	NOAEL	1.7	3.3	1.7	3.3	1.7	3.3	1.7	3.3	1.7	3.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	LOAEL	5.0	10.0	5.0	10.0	5.0	10.0	5.0	10.0	5.0	10.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	NOAEL	0.833	0.827	0.167	0.496	0.278	0.827	0.167	0.496	0.167	0.496	0.043	0.087	0.043	0.087	0.043	0.087	0.043	0.087	0.043	0.087	0.043	0.087
	LOAEL	2.500	1.653	0.500	0.992	0.833	1.653	0.500	0.992	0.500	0.992	1.195	2.390	1.195	2.390	1.195	2.390	1.195	2.390	1.195	2.390	1.195	2.390
Chromium	NOAEL	400	800	400	800	400	800	400	800	400	800	0.100	0.200	0.100	0.200	0.100	0.200	0.100	0.200	0.100	0.200	0.100	0.200
	LOAEL	1200	2400	1200	2400	1200	2400	1200	2400	1200	2400	0.500	1.000	0.500	1.000	0.500	1.000	0.500	1.000	0.500	1.000	0.500	1.000
Copper	NOAEL	3.800	168.000	17.680	8.840	1.267	56.000	0.760	33.600	4.420	2.210	2.010	4.020	2.010	4.020	2.010	4.020	2.010	4.020	2.010	4.020	2.010	4.020
	LOAEL	9.040	362.000	25.680	12.840	3.013	120.667	1.808	72.400	6.420	3.210	3.015	6.030	3.015	6.030	3.015	6.030	3.015	6.030	3.015	6.030	3.015	6.030
Lead	NOAEL	0.208	0.417	0.156	0.312	0.069	0.139	0.042	0.083	0.208	0.416	0.438	0.875	0.438	0.875	0.438	0.875	0.438	0.875	0.438	0.875	0.438	0.875
	LOAEL	0.625	1.250	0.306	0.612	0.208	0.417	0.125	0.250	0.408	0.816	0.875	1.750	0.875	1.750	0.875	1.750	0.875	1.750	0.875	1.750	0.875	1.750
Manganese	NOAEL	8.8	17.6	8.8	17.6	8.8	17.6	8.8	17.6	8.8	17.6	32.6	65.1	32.6	65.1	32.6	65.1	32.6	65.1	32.6	65.1	32.6	65.1
	LOAEL	28.4	56.8	28.4	56.8	28.4	56.8	28.4	56.8	28.4	56.8	97.7	195.4	97.7	195.4	97.7	195.4	97.7	195.4	97.7	195.4	97.7	195.4
Mercury	NOAEL	3.300	6.600	0.685	1.370	2.200	4.400	1.320	2.640	0.171	0.343	0.045	0.090	0.045	0.090	0.045	0.090	0.045	0.090	0.045	0.090	0.045	0.090
	LOAEL	9.900	19.800	2.055	4.110	6.600	13.200	3.960	7.920	0.514	1.028	0.090	0.181	0.090	0.181	0.090	0.181	0.090	0.181	0.090	0.181	0.090	0.181
Molybdenum	NOAEL	0.023	0.011	0.023	0.011	0.023	0.011	0.023	0.011	0.023	0.011	1.178	2.356	1.178	2.356	1.178	2.356	1.178	2.356	1.178	2.356	1.178	2.356
	LOAEL	0.523	0.261	0.523	0.261	0.523	0.261	0.523	0.261	0.523	0.261	3.533	7.067	3.533	7.067	3.533	7.067	3.533	7.067	3.533	7.067	3.533	7.067
Thallium	NOAEL	0.002	0.003	0.001	0.002	0.001	0.002	0.001	0.002	0.001	0.002	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	LOAEL	0.005	0.010	0.003	0.006	0.003	0.006	0.003	0.006	0.003	0.006	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	NOAEL	0.556	1.111	0.333	0.667	0.556	1.111	0.333	0.667	0.333	0.667	1.138	2.275	1.138	2.275	1.138	2.275	1.138	2.275	1.138	2.275	1.138	2.275
	LOAEL	1.667	3.333	1.000	2.000	1.667	3.333	1.000	2.000	1.000	2.000	3.413	6.826	3.413	6.826	3.413	6.826	3.413	6.826	3.413	6.826	3.413	6.826
Zinc	NOAEL	20.000	40.000	155.500	311.000	20.000	40.000	12.000	24.000	38.875	77.750	13.101	26.202	13.101	26.202	13.101	26.202	13.101	26.202	13.101	26.202	13.101	26.202
	LOAEL	40.000	80.000	466.500	933.000	40.000	80.000	24.000	48.000	116.625	233.250	39.303	78.605	39.303	78.605	39.303	78.605	39.303	78.605	39.303	78.605	39.303	78.605

All units in mg/kg BW-day

**Table 8-7a**  
**Summary of Hazard Indices for Wildlife Receptors**

**Cliff Swallow**

**HAZARD INDEX SUMMARY**

Station	Based on NOAEL TRV							Based on LOAEL TRV						
	WWC - Reach A	WWC - Reach B	WWC - Reach C	WWC - Reach D	BFR - Reach A	BFR - Reach B	SPC	WWC - Reach A	WWC - Reach B	WWC - Reach C	WWC - Reach D	BFR - Reach A	BFR - Reach B	SPC
Aluminum	5E+00		5E+00	5E+00	4E+00		2E+00	1E+00		9E-01	9E-01	9E-01		3E-01
Antimony														
Arsenic	6E-03	8E-03	2E+01	1E+01	5E-02	1E-03	1E-01	7E-04	1E-03	2E+00	1E+00	6E-03	1E-04	1E-02
Barium	4E-01		2E-01	2E-01	2E-01		1E-01	2E-01		1E-01	9E-02	1E-01		7E-02
Beryllium														
Cadmium	3E-02		5E-02	7E-02	5E-02		8E-02	9E-04		2E-03	2E-03	2E-03		3E-03
Chromium	2E-01		3E-01	3E-01	2E-01		1E-01	5E-02		6E-02	5E-02	4E-02		2E-02
Copper	2E-02		7E-02	5E-02	2E-02		1E-02	1E-02		5E-02	3E-02	1E-02		8E-03
Lead	7E-02		1E-01	8E-02	6E-02		9E-02	4E-02		6E-02	4E-02	3E-02		5E-02
Manganese	2E-02		7E-02	7E-02	3E-02		1E-02	8E-03		2E-02	2E-02	1E-02		5E-03
Mercury	3E-02		6E-02	3E-02	1E-03		7E-02	2E-02		3E-02	2E-02	5E-04		3E-02
Molybdenum	6E-04		4E-03	3E-03	5E-03		1E-03	2E-04		1E-03	8E-04	2E-03		4E-04
Thallium														
Vanadium	3E-02		5E-02	4E-02	5E-02		2E-02	8E-03		2E-02	1E-02	2E-02		7E-03
Zinc	3E-02	6E-02	2E-02	2E-02	1E-02	9E-05	8E-03	1E-02	2E-02	6E-03	6E-03	3E-03	3E-05	3E-03

HI values greater than 1E+00 are shaded.

**Table 8-7b**  
**Summary of Hazard Indices for Wildlife Receptors**

**American Robin**

**HAZARD INDEX SUMMARY**

Station	Based on NOAEL TRV							Based on LOAEL TRV						
	WWC - Reach A	WWC - Reach B	WWC - Reach C	WWC - Reach D	BFR - Reach A	BFR - Reach B	SPC	WWC - Reach A	WWC - Reach B	WWC - Reach C	WWC - Reach D	BFR - Reach A	BFR - Reach B	SPC
Aluminum	2E+01		2E+01	2E+01	2E+01		8E+00	5E+00		4E+00	4E+00	4E+00		2E+00
Antimony														
Arsenic	7E-01	5E-03	8E+01	5E+01	2E-01	7E-04	5E-01	8E-02	6E-04	9E+00	6E+00	3E-02	8E-05	6E-02
Barium	2E+00		1E+00	9E-01	9E-01		7E-01	9E-01		5E-01	4E-01	5E-01		3E-01
Beryllium														
Cadmium	2E-01		3E-01	4E-01	2E-01		4E-01	7E-03		1E-02	2E-02	9E-03		1E-02
Chromium	1E+00		1E+00	1E+00	9E-01		5E-01	2E-01		3E-01	2E-01	2E-01		1E-01
Copper	6E-02		3E-01	2E-01	1E-01		3E-02	4E-02		2E-01	1E-01	6E-02		2E-02
Lead	3E-01		6E-01	4E-01	3E-01		4E-01	2E-01		3E-01	2E-01	1E-01		2E-01
Manganese	1E-01		3E-01	4E-01	1E-01		7E-02	4E-02		1E-01	1E-01	5E-02		2E-02
Mercury	2E-01		3E-01	2E-01	5E-03		3E-01	9E-02		1E-01	9E-02	2E-03		2E-01
Molybdenum	3E-03		2E-02	1E-02	2E-02		5E-03	1E-03		7E-03	4E-03	7E-03		2E-03
Thallium														
Vanadium	1E-01		2E-01	2E-01	2E-01		9E-02	4E-02		7E-02	7E-02	8E-02		3E-02
Zinc	5E-02	4E-02	7E-02	6E-02	5E-02	6E-05	2E-02	2E-02	1E-02	2E-02	2E-02	2E-02	2E-05	7E-03

HI values greater than 1E+00 are shaded.

**Table 8-7c**  
**Summary of Hazard Indices for Wildlife Receptors**

**Masked Shrew**

**HAZARD INDEX SUMMARY**

Station	Based on NOAEL TRV							Based on LOAEL TRV						
	WWC - Reach A	WWC - Reach B	WWC - Reach C	WWC - Reach D	BFR - Reach A	BFR - Reach B	SPC	WWC - Reach A	WWC - Reach B	WWC - Reach C	WWC - Reach D	BFR - Reach A	BFR - Reach B	SPC
Aluminum	3E+02		3E+02	3E+02	3E+02		1E+02	7E+01		7E+01	7E+01	6E+01		2E+01
Antimony	4E+01		1E+02	1E+02	5E+00		8E+01	1E+01		3E+01	4E+01	2E+00		3E+01
Arsenic	6E+00	1E-02	2E+03	2E+03	8E+00	1E-03	2E+01	2E+00	4E-03	8E+02	6E+02	3E+00	4E-04	6E+00
Barium	1E+01		7E+00	6E+00	6E+00		4E+00	4E+00		2E+00	2E+00	2E+00		1E+00
Beryllium	1E-01		2E-02	2E-02	2E-02		1E-02	4E-02		6E-03	6E-03	7E-03		5E-03
Cadmium	1E-01		2E-01	3E-01	2E-01		3E-01	6E-02		1E-01	1E-01	1E-01		1E-01
Chromium	1E-03		2E-03	1E-03	1E-03		6E-04	4E-04		5E-04	5E-04	4E-04		2E-04
Copper	3E-02		2E-01	1E-01	5E-02		2E-02	2E-02		8E-02	6E-02	3E-02		9E-03
Lead	2E+01		3E+01	2E+01	1E+01		2E+01	6E+00		1E+01	6E+00	4E+00		7E+00
Manganese	2E+00		6E+00	6E+00	3E+00		1E+00	6E-01		2E+00	2E+00	8E-01		4E-01
Mercury	3E-02		5E-02	3E-02	8E-04		5E-02	9E-03		2E-02	9E-03	3E-04		2E-02
Molybdenum	3E+00		2E+01	1E+01	2E+01		5E+00	1E-01		9E-01	5E-01	9E-01		2E-01
Thallium	1E+01		5E+01	4E+01	1E+01		2E+01	5E+00		2E+01	1E+01	5E+00		6E+00
Vanadium	2E+00		4E+00	3E+00	4E+00		2E+00	6E-01		1E+00	1E+00	1E+00		5E-01
Zinc	2E-01	5E-02	3E-01	2E-01	3E-01	8E-05	1E-01	9E-02	2E-02	2E-01	1E-01	1E-01	4E-05	6E-02

HI values greater than 1E+00 are shaded.

**Table 8-7d**  
**Summary of Hazard Indices for Wildlife Receptors**

**Meadow Vole**

**HAZARD INDEX SUMMARY**

Station	Based on NOAEL TRV							Based on LOAEL TRV						
	WWC - Reach A	WWC - Reach B	WWC - Reach C	WWC - Reach D	BFR - Reach A	BFR - Reach B	SPC	WWC - Reach A	WWC - Reach B	WWC - Reach C	WWC - Reach D	BFR - Reach A	BFR - Reach B	SPC
Aluminum	6E+01		6E+01	6E+01	5E+01		2E+01	1E+01		1E+01	1E+01	1E+01		4E+00
Antimony	7E+00		2E+01	2E+01	8E-01		1E+01	2E+00		6E+00	7E+00	3E-01		5E+00
Arsenic	1E-01	5E-03	4E+02	3E+02	1E+00	7E-04	3E+00	5E-02	2E-03	1E+02	1E+02	5E-01	2E-04	1E+00
Barium	1E+00		7E-01	6E-01	6E-01		5E-01	4E-01		2E-01	2E-01	2E-01		2E-01
Beryllium	2E-02		3E-03	3E-03	4E-03		3E-03	6E-03		1E-03	1E-03	1E-03		8E-04
Cadmium	1E-02		2E-02	3E-02	2E-02		3E-02	6E-03		1E-02	1E-02	1E-02		2E-02
Chromium	2E-04		3E-04	2E-04	2E-04		1E-04	7E-05		9E-05	8E-05	6E-05		4E-05
Copper	3E-03		2E-02	1E-02	6E-03		2E-03	2E-03		9E-03	6E-03	3E-03		1E-03
Lead	2E+00		3E+00	2E+00	1E+00		2E+00	6E-01		1E+00	6E-01	5E-01		8E-01
Manganese	4E-01		1E+00	1E+00	5E-01		2E-01	1E-01		3E-01	4E-01	1E-01		7E-02
Mercury	3E-03		5E-03	3E-03	9E-05		6E-03	1E-03		2E-03	1E-03	3E-05		2E-03
Molybdenum	5E-01		4E+00	2E+00	4E+00		9E-01	2E-02		2E-01	9E-02	2E-01		4E-02
Thallium	2E+00		9E+00	8E+00	3E+00		3E+00	6E-01		3E+00	3E+00	9E-01		1E+00
Vanadium	2E-01		4E-01	3E-01	4E-01		2E-01	7E-02		1E-01	1E-01	1E-01		5E-02
Zinc	2E-02	2E-02	3E-02	3E-02	3E-02	4E-05	1E-02	1E-02	1E-02	2E-02	1E-02	1E-02	2E-05	6E-03

HI values greater than 1E+00 are shaded.

**Table 8-7e**  
**Summary of Hazard Indices for Wildlife Receptors**

**Deer Mouse**

**HAZARD INDEX SUMMARY**

Station	Based on NOAEL TRV							Based on LOAEL TRV						
	WWC - Reach A	WWC - Reach B	WWC - Reach C	WWC - Reach D	BFR - Reach A	BFR - Reach B	SPC	WWC - Reach A	WWC - Reach B	WWC - Reach C	WWC - Reach D	BFR - Reach A	BFR - Reach B	SPC
Aluminum	1E+01		1E+01	1E+01	1E+01		5E+00	3E+00		3E+00	3E+00	3E+00		1E+00
Antimony	4E-01		1E+00	1E+00	5E-02		8E-01	1E-01		3E-01	4E-01	2E-02		3E-01
Arsenic	6E-03	2E-03	5E+00	3E+00	2E-02	2E-04	3E-02	2E-03	6E-04	2E+00	1E+00	5E-03	8E-05	1E-02
Barium	3E-01		2E-01	2E-01	1E-01		1E-01	1E-01		6E-02	5E-02	5E-02		4E-02
Beryllium	4E-03		8E-04	8E-04	9E-04		6E-04	1E-03		3E-04	3E-04	3E-04		2E-04
Cadmium	3E-03		6E-03	7E-03	5E-03		8E-03	2E-03		3E-03	3E-03	2E-03		4E-03
Chromium	5E-05		6E-05	6E-05	4E-05		3E-05	2E-05		2E-05	2E-05	1E-05		9E-06
Copper	3E-04		1E-03	1E-03	4E-04		2E-04	1E-04		7E-04	5E-04	2E-04		9E-05
Lead	1E-01		2E-01	1E-01	1E-01		2E-01	5E-02		8E-02	5E-02	4E-02		6E-02
Manganese	1E-01		2E-01	3E-01	1E-01		5E-02	4E-02		8E-02	9E-02	3E-02		2E-02
Mercury	5E-04		8E-04	4E-04	1E-05		9E-04	2E-04		3E-04	1E-04	4E-06		3E-04
Molybdenum	1E-01		8E-01	5E-01	9E-01		2E-01	5E-03		3E-02	2E-02	4E-02		9E-03
Thallium	4E-01		1E+00	1E+00	4E-01		5E-01	1E-01		4E-01	4E-01	1E-01		2E-01
Vanadium	5E-02		9E-02	8E-02	1E-01		4E-02	2E-02		3E-02	3E-02	3E-02		1E-02
Zinc	1E-02	3E-02	9E-03	8E-03	6E-03	4E-05	4E-03	7E-03	1E-02	4E-03	4E-03	3E-03	2E-05	2E-03

HI values greater than 1E+00 are shaded.

**Table 8-7f**  
**Summary of Hazard Indices for Wildlife Receptors**

**Red Fox**

**HAZARD INDEX SUMMARY**

Station	Based on NOAEL TRV							Based on LOAEL TRV						
	WWC - Reach A	WWC - Reach B	WWC - Reach C	WWC - Reach D	BFR - Reach A	BFR - Reach B	SPC	WWC - Reach A	WWC - Reach B	WWC - Reach C	WWC - Reach D	BFR - Reach A	BFR - Reach B	SPC
Aluminum	3E+00		2E+00	2E+00	2E+00		8E-01	5E-01		5E-01	5E-01	4E-01		2E-01
Antimony	9E-02		2E-01	2E-01	8E-03		2E-01	3E-02		6E-02	7E-02	3E-03		5E-02
Arsenic	5E-03	5E-03	1E+01	7E+00	4E-02	7E-04	8E-02	2E-03	2E-03	4E+00	2E+00	1E-02	2E-04	3E-02
Barium	8E-02		5E-02	4E-02	4E-02		3E-02	3E-02		2E-02	1E-02	1E-02		1E-02
Beryllium	8E-04		1E-04	1E-04	2E-04		1E-04	3E-04		4E-05	4E-05	5E-05		4E-05
Cadmium	8E-04		1E-03	2E-03	1E-03		2E-03	4E-04		7E-04	1E-03	7E-04		1E-03
Chromium	1E-05		1E-05	1E-05	8E-06		6E-06	3E-06		4E-06	4E-06	3E-06		2E-06
Copper	4E-03		2E-02	1E-02	6E-03		3E-03	3E-03		1E-02	1E-02	4E-03		2E-03
Lead	3E-02		4E-02	3E-02	2E-02		3E-02	1E-02		2E-02	1E-02	1E-02		2E-02
Manganese	2E-02		4E-02	5E-02	2E-02		9E-03	5E-03		1E-02	1E-02	6E-03		3E-03
Mercury	2E-03		3E-03	2E-03	5E-05		3E-03	5E-04		9E-04	5E-04	2E-05		1E-03
Molybdenum	2E-02		1E-01	9E-02	2E-01		4E-02	9E-04		6E-03	4E-03	7E-03		2E-03
Thallium	7E-02		3E-01	3E-01	1E-01		1E-01	2E-02		1E-01	1E-01	4E-02		4E-02
Vanadium	1E-02		3E-02	2E-02	3E-02		1E-02	5E-03		9E-03	8E-03	1E-02		4E-03
Zinc	3E-03	8E-03	1E-03	1E-03	6E-04	1E-05	6E-04	1E-03	3E-03	4E-04	5E-04	2E-04	4E-06	2E-04

HI values greater than 1E+00 are shaded.

**Table 8-7g**  
**Summary of Hazard Indices for Wildlife Receptors**

**American Kestrel**

**HAZARD INDEX SUMMARY**

Station	Based on NOAEL TRV							Based on LOAEL TRV						
	WWC - Reach A	WWC - Reach B	WWC - Reach C	WWC - Reach D	BFR - Reach A	BFR - Reach B	SPC	WWC - Reach A	WWC - Reach B	WWC - Reach C	WWC - Reach D	BFR - Reach A	BFR - Reach B	SPC
<b>Aluminum</b>	2E+00		1E+00	1E+00	1E+00		5E-01	3E-01		3E-01	3E-01	3E-01		1E-01
<b>Antimony</b>														
<b>Arsenic</b>	4E-03	5E-03	5E+00	3E+00	2E-02	6E-04	4E-02	5E-04	5E-04	6E-01	4E-01	2E-03	7E-05	4E-03
<b>Barium</b>	1E-01		7E-02	6E-02	6E-02		4E-02	6E-02		3E-02	3E-02	3E-02		2E-02
<b>Beryllium</b>														
<b>Cadmium</b>	1E-02		2E-02	2E-02	2E-02		3E-02	4E-04		7E-04	8E-04	6E-04		9E-04
<b>Chromium</b>	9E-02		1E-01	1E-01	6E-02		5E-02	2E-02		2E-02	2E-02	1E-02		1E-02
<b>Copper</b>	7E-03		2E-02	2E-02	6E-03		6E-03	5E-03		2E-02	1E-02	4E-03		4E-03
<b>Lead</b>	2E-02		4E-02	2E-02	2E-02		3E-02	1E-02		2E-02	1E-02	8E-03		2E-02
<b>Manganese</b>	8E-03		2E-02	2E-02	9E-03		5E-03	3E-03		7E-03	8E-03	3E-03		2E-03
<b>Mercury</b>	1E-02		2E-02	1E-02	3E-04		2E-02	5E-03		1E-02	6E-03	2E-04		1E-02
<b>Molybdenum</b>	2E-04		1E-03	8E-04	1E-03		3E-04	6E-05		4E-04	3E-04	5E-04		1E-04
<b>Thallium</b>														
<b>Vanadium</b>	8E-03		1E-02	1E-02	2E-02		6E-03	3E-03		5E-03	4E-03	5E-03		2E-03
<b>Zinc</b>	2E-02	3E-02	9E-03	1E-02	3E-03	5E-05	6E-03	6E-03	1E-02	3E-03	3E-03	1E-03	2E-05	2E-03

HI values greater than 1E+00 are shaded.

**Table 8-7h**  
**Summary of Hazard Indices for Wildlife Receptors**

**Great Horned Owl**

**HAZARD INDEX SUMMARY**

Station	Based on NOAEL TRV							Based on LOAEL TRV						
	WWC - Reach A	WWC - Reach B	WWC - Reach C	WWC - Reach D	BFR - Reach A	BFR - Reach B	SPC	WWC - Reach A	WWC - Reach B	WWC - Reach C	WWC - Reach D	BFR - Reach A	BFR - Reach B	SPC
Aluminum	3E-01		3E-01	3E-01	3E-01	4E-04	1E-01	7E-02		6E-02	6E-02	6E-02	8E-05	2E-02
Antimony														
Arsenic	2E-03	2E-03	1E+00	7E-01	4E-03	3E-04	8E-03	2E-04	2E-04	1E-01	8E-02	5E-04	4E-05	9E-04
Barium	2E-02		1E-02	1E-02	1E-02	1E-05	1E-02	1E-02		7E-03	6E-03	6E-03	7E-06	5E-03
Beryllium														
Cadmium	2E-03		3E-03	5E-03	3E-03	6E-06	5E-03	7E-05		1E-04	2E-04	1E-04	2E-07	2E-04
Chromium	2E-02		2E-02	2E-02	1E-02	1E-04	1E-02	4E-03		4E-03	4E-03	3E-03	3E-05	2E-03
Copper	1E-03		5E-03	3E-03	1E-03	7E-06	9E-04	7E-04		3E-03	2E-03	9E-04	5E-06	6E-04
Lead	5E-03		8E-03	5E-03	4E-03	2E-06	7E-03	2E-03		4E-03	2E-03	2E-03	9E-07	3E-03
Manganese	2E-03		5E-03	5E-03	2E-03	7E-06	1E-03	5E-04		2E-03	2E-03	7E-04	2E-06	3E-04
Mercury	2E-03		4E-03	2E-03	1E-04	5E-05	5E-03	1E-03		2E-03	1E-03	5E-05	2E-05	3E-03
Molybdenum	4E-05		3E-04	2E-04	3E-04		7E-05	1E-05		9E-05	5E-05	1E-04		2E-05
Thallium														
Vanadium	2E-03		3E-03	3E-03	3E-03	6E-06	1E-03	6E-04		1E-03	9E-04	1E-03	2E-06	4E-04
Zinc	6E-03	1E-02	2E-03	2E-03	7E-04	9E-05	1E-03	2E-03	4E-03	6E-04	8E-04	2E-04	3E-05	4E-04

HI values greater than 1E+00 are shaded.

**Table 8-7i**  
**Summary of Hazard Indices for Wildlife Receptors**

**American Dipper**

**HAZARD INDEX SUMMARY**

Station	Based on NOAEL TRV							Based on LOAEL TRV						
	WWC - Reach A	WWC - Reach B	WWC - Reach C	WWC - Reach D	BFR - Reach A	BFR - Reach B	SPC	WWC - Reach A	WWC - Reach B	WWC - Reach C	WWC - Reach D	BFR - Reach A	BFR - Reach B	SPC
<b>Aluminum</b>	8E-01	8E-01	7E-01	1E+00	5E-01	7E-01	3E-01	2E-01	2E-01	1E-01	2E-01	1E-01	1E-01	6E-02
<b>Antimony</b>														
<b>Arsenic</b>	3E-01	4E-01	1E+00	7E-01	1E-02	1E+00	1E-02	3E-02	5E-02	1E-01	8E-02	1E-03	1E-01	1E-03
<b>Barium</b>	5E-02	1E-01	5E-02	5E-02	6E-02	4E-02	3E-02	2E-02	5E-02	2E-02	2E-02	3E-02	2E-02	2E-02
<b>Beryllium</b>														
<b>Cadmium</b>	1E-02	1E-02	1E-02	1E-02	1E-02	1E-02	3E-03	4E-04	5E-04	4E-04	4E-04	5E-04	4E-04	1E-04
<b>Chromium</b>	7E-02	1E-01	6E-02	6E-02	3E-02	4E-02	3E-02	1E-02	2E-02	1E-02	1E-02	6E-03	8E-03	5E-03
<b>Copper</b>	8E-03	2E-02	2E-02	7E-03	3E-03	6E-03	2E-03	5E-03	1E-02	1E-02	5E-03	2E-03	4E-03	1E-03
<b>Lead</b>	1E-02	2E-01	3E-02	1E-02	8E-03	1E-02	1E-02	6E-03	9E-02	2E-02	6E-03	4E-03	7E-03	5E-03
<b>Manganese</b>	3E-02	1E-02	9E-03	1E-02	6E-03	1E-02	2E-03	9E-03	4E-03	3E-03	4E-03	2E-03	4E-03	7E-04
<b>Mercury</b>	1E-03	2E-03	5E-03	3E-03	3E-04	1E-03	6E-04	7E-04	1E-03	2E-03	1E-03	1E-04	6E-04	3E-04
<b>Molybdenum</b>	5E-04	1E-03	8E-04	5E-04	1E-03	6E-04	2E-05	2E-04	3E-04	3E-04	2E-04	4E-04	2E-04	7E-06
<b>Thallium</b>														
<b>Vanadium</b>	8E-03	1E-02	9E-03	1E-02	1E-02	1E-02	3E-03	3E-03	4E-03	3E-03	5E-03	4E-03	4E-03	1E-03
<b>Zinc</b>	2E-02	5E-02	5E-03	6E-03	2E-03	3E-03	2E-03	7E-03	2E-02	2E-03	2E-03	6E-04	9E-04	5E-04

HI values greater than 1E+00 are shaded.

**Table 8-7j**  
**Summary of Hazard Indices for Wildlife Receptors**

**Belted Kingfisher**

**HAZARD INDEX SUMMARY**

Station	Based on NOAEL TRV							Based on LOAEL TRV						
	WWC - Reach A	WWC - Reach B	WWC - Reach C	WWC - Reach D	BFR - Reach A	BFR - Reach B	SPC	WWC - Reach A	WWC - Reach B	WWC - Reach C	WWC - Reach D	BFR - Reach A	BFR - Reach B	SPC
<b>Aluminum</b>	3E+00	4E+00	3E+00	4E+00	2E+00	3E+00	1E+00	6E-01	7E-01	5E-01	8E-01	5E-01	6E-01	2E-01
<b>Antimony</b>														
<b>Arsenic</b>	8E-01	2E+00	4E+00	3E+00	5E-02	5E+00	5E-02	9E-02	2E-01	5E-01	3E-01	6E-03	5E-01	5E-03
<b>Barium</b>	2E-01	4E-01	2E-01	2E-01	3E-01	2E-01	1E-01	8E-02	2E-01	1E-01	9E-02	1E-01	9E-02	7E-02
<b>Beryllium</b>														
<b>Cadmium</b>	3E-02	6E-02	4E-02	4E-02	6E-02	4E-02	1E-02	1E-03	2E-03	2E-03	2E-03	2E-03	2E-03	4E-04
<b>Chromium</b>	3E-01	4E-01	3E-01	3E-01	2E-01	2E-01	2E-01	5E-02	8E-02	5E-02	5E-02	3E-02	4E-02	3E-02
<b>Copper</b>	3E-02	6E-02	8E-02	3E-02	1E-02	2E-02	6E-03	2E-02	4E-02	5E-02	2E-02	1E-02	1E-02	4E-03
<b>Lead</b>	5E-02	8E-01	1E-01	5E-02	4E-02	6E-02	4E-02	2E-02	4E-01	7E-02	3E-02	2E-02	3E-02	2E-02
<b>Manganese</b>	5E-02	5E-02	4E-02	4E-02	3E-02	4E-02	8E-03	2E-02	2E-02	1E-02	1E-02	9E-03	1E-02	3E-03
<b>Mercury</b>	6E-03	1E-02	3E-02	2E-02	7E-03	1E-02	7E-03	3E-03	5E-03	1E-02	8E-03	4E-03	7E-03	3E-03
<b>Molybdenum</b>	2E-03	4E-03	3E-03	2E-03	5E-03	3E-03	9E-05	6E-04	1E-03	1E-03	8E-04	2E-03	8E-04	3E-05
<b>Thallium</b>														
<b>Vanadium</b>	3E-02	5E-02	4E-02	6E-02	6E-02	5E-02	1E-02	1E-02	2E-02	1E-02	2E-02	2E-02	2E-02	4E-03
<b>Zinc</b>	3E-02	5E-02	2E-02	2E-02	2E-02	2E-02	1E-02	9E-03	2E-02	8E-03	6E-03	5E-03	7E-03	4E-03

HI values greater than 1E+00 are shaded.

**Table 8-7k**  
**Summary of Hazard Indices for Wildlife Receptors**

**Mink**

**HAZARD INDEX SUMMARY**

Station	Based on NOAEL TRV							Based on LOAEL TRV						
	WWC - Reach A	WWC - Reach B	WWC - Reach C	WWC - Reach D	BFR - Reach A	BFR - Reach B	SPC	WWC - Reach A	WWC - Reach B	WWC - Reach C	WWC - Reach D	BFR - Reach A	BFR - Reach B	SPC
<b>Aluminum</b>	1E+00	2E+00	1E+00	2E+00	1E+00	1E+00	6E-01	3E-01	3E-01	3E-01	4E-01	2E-01	3E-01	1E-01
<b>Antimony</b>	2E-01	1E-01	2E-01	6E-02	3E-02	4E-02	6E-02	8E-02	3E-02	6E-02	2E-02	1E-02	1E-02	2E-02
<b>Arsenic</b>	7E-01	1E+00	3E+00	2E+00	4E-02	4E+00	4E-02	2E-01	4E-01	1E+00	8E-01	1E-02	1E+00	1E-02
<b>Barium</b>	4E-02	9E-02	4E-02	4E-02	5E-02	4E-02	3E-02	1E-02	3E-02	1E-02	1E-02	2E-02	1E-02	9E-03
<b>Beryllium</b>	2E-06		2E-06	2E-06			2E-06	7E-07		5E-07	5E-07			5E-07
<b>Cadmium</b>	1E-03	1E-03	1E-03	1E-03	2E-03	1E-03	4E-04	5E-04	7E-04	6E-04	6E-04	8E-04	5E-04	2E-04
<b>Chromium</b>	1E-05	2E-05	1E-05	1E-05	6E-06	7E-06	8E-06	4E-06	5E-06	4E-06	4E-06	2E-06	2E-06	3E-06
<b>Copper</b>	2E-03	4E-03	5E-03	2E-03	1E-03	2E-03	6E-04	1E-03	3E-03	4E-03	1E-03	7E-04	1E-03	4E-04
<b>Lead</b>	2E-02	3E-01	6E-02	2E-02	2E-02	3E-02	2E-02	1E-02	2E-01	3E-02	1E-02	8E-03	1E-02	1E-02
<b>Manganese</b>	4E-02	3E-02	2E-02	2E-02	1E-02	2E-02	5E-03	1E-02	8E-03	7E-03	7E-03	5E-03	7E-03	1E-03
<b>Mercury</b>	6E-05	1E-04	3E-04	2E-04	1E-04	2E-04	1E-04	2E-05	3E-05	1E-04	7E-05	3E-05	6E-05	4E-05
<b>Molybdenum</b>	6E-02	1E-01	1E-01	7E-02	2E-01	8E-02	3E-03	3E-03	6E-03	5E-03	3E-03	7E-03	3E-03	1E-04
<b>Thallium</b>	5E-04		7E-04	5E-04			7E-04	2E-04		2E-04	2E-04			2E-04
<b>Vanadium</b>	2E-02	3E-02	2E-02	3E-02	3E-02	2E-02	7E-03	6E-03	9E-03	7E-03	1E-02	1E-02	8E-03	2E-03
<b>Zinc</b>	1E-03	3E-03	4E-04	5E-04	2E-04	3E-04	3E-04	4E-04	9E-04	1E-04	2E-04	8E-05	1E-04	9E-05

HI values greater than 1E+00 are shaded.

**Table 8-8 Summary of Results of Small Mammal Histological Evaluations (US EPA, 2001b)**

Sample Location	Number of animals examined	Number with Histological Abnormalities (%)			Description
		Liver	Kidney	Spleen	
WWC-R-01 (ref)	8	0 (0%)	0 (0%)	0 (0%)	No abnormalities noted in any tissue
SPC-R-12 (ref)	10	1 (10%)	0 (0%)	3 (30%)	Multifocal collections of lymphocytes and plasma cells in the liver of shrew. Marked hematopoietic activity with mild autolysis and lymphoid depletion in spleen of shrew. Some congestion in spleen of deer mouse. No abnormalities noted in jumping mouse or either vole species.
WWC-05	16	0 (0%)	0 (0%)	6 (38)	Extramedullary hematopoiesis , focal areas of hemorrhage and necrosis, acute congestion, focal hematoma, and possible bone marrow reaction noted in deer mouse. No abnormalities noted in the masked shrew.
WWC-06	13	2 (15%)	0 (0%)	8 (62)	Mild autolysis and extramedullary hematopoiesis in spleen of jumping mouse. Liver with parasitic flukes. Multifocal aggregates of neutrophils, splenitis, mild to moderate to prominent extramedullary hematopoiesis, extensive hematopoiesis with acute congestion in spleen of Deer mouse. Liver with parasitic flukes and extensive extramedullary hematopoiesis in the spleen of shrew.
WWC-08	4	1 (25%)	1 (25%)	1 (25%)	Multifocal aggregates of inflammatory cells in the renal tissue. Liver flukes and areas of chronic cholangiohepatitis and fibrosis. Evidence of lobular hyperplasia and some megacytosis. Extramedullary hematopoiesis suggest early myeloproliferative disease. All in Deer mouse.

Table 8-8 (histo).wpd

**Table 9-1. Amphibian Toxicity Benchmarks**

COPC	Data from AQUIRE				Calculated TRV (ug/L) (a)	
	Species (lifestage)	Study Duration	Hardness (mg/L)	LC50 (ug/L)	Total	Dissolved
Aluminum	American toad (tadpole)	96 hrs	na	1,168	584	584
	Leopard frog (embryo)	96 hrs	na	834	417	417
	Eastern Narrow-Mouthed Toad (eggs)	168 hrs	195	50	25	25
	Marbled salamander (eggs)	192 hrs	93	2,280	1,140	1,140
Copper	Fowler's toad (eggs)	168 hrs	100	26,960	13,480	12,941
	Marbled salamander (eggs)	192 hrs	100	770	385	370
	Common Indian toad (2 cm, 100 mg)	96 hrs	185	320	90	86
	Frog (tadpole/20 mm, 500 mg)	96 hrs	20	39	89	85
	Tiger frog, Indian bullfrog (larva)	96 hrs	240	389	85	82
	Leopard frog (eggs)	192 hrs	100	50	25	24
	Southern grey tree frog (eggs)	168 hrs	100	40	20	19
	Eastern Narrow-Mouthed Toad (eggs)	168 hrs	195	40	11	10
Cyanide	No data (b)	--	--	--	--	--
Lead	Frog (20 mm, 500 mg)	96 hrs	20	33,280	129,105	102,122
	Eastern Narrow-Mouthed Toad (eggs)	168 hrs	195	40	8.5	6.8
Selenium	Eastern Narrow-Mouthed Toad (eggs)	168 hrs	195	90	45	45
Silver	Frog (20 mm, 500 mg)	96 hrs	20	26	205	174
	Eastern Narrow-Mouthed Toad (eggs)	168 hrs	195	10	1.6	1.3
	Common indian toad (2 cm, 100 mg)	96 hrs	185	4.1	0.7	0.6

(a) Calculated TRV is equal to the LC50/2, adjusted to a hardness of 100 mg/L

(b) Data were available for avoidance, but avoidance is not a reliable toxicity metric

**Table 10-1**  
**Summary of Qualitative COPCs**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

Parameters	Aquatic Receptors				Wildlife Receptors						Plants & Soil Invertebrates	
	Surface Water		Sediment		Surface Water		Sediment		Soil		Soil	
	Type 1	Type 2	Type 1	Type 2	Type 1	Type 2	Type 1	Type 2	Type 1	Type 2	Type 1	Type 2
Antimony	X		X		X							
Barium	X		X									
Beryllium	X		X		X							
Boron	X		X									
Cadmium		X										
Calcium	X		X				X		X		X	
Cobalt	X		X				X		X			
Cyanide			X								X	
Iron					X		X		X			
Lithium	X		na	na		X	na	na	na	na	na	na
Magnesium	X		X				X		X		X	
Manganese	X											
Molybdenum	X		X									
Phosphorus	X		na	na	X		na	na	na	na	na	na
Potassium	X		X				X		X		X	
Selenium			X									
Silica	X		na	na	X		na	na	na	na	na	na
Silver					X		X		X			
Sodium	X		X				X		X		X	
Strontium	X		na	na		X	na	na	na	na	na	na
Thallium	X		X					X				
Uranium	X		na	na		X	na	na	na	na	na	na
Vanadium	X		X									
<b>Total</b>	<b>18</b>	<b>1</b>	<b>14</b>	<b>0</b>	<b>6</b>	<b>3</b>	<b>7</b>	<b>1</b>	<b>7</b>	<b>0</b>	<b>5</b>	<b>0</b>

**Table 11-1. Assessment of Testable Hypotheses for Stream Function and Viability**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

Testable Hypothesis	Measurement Endpoint	Observation	Effect Score	Discussion	Conclusion
The concentrations of COPCs in surface water on-site are not greater than benchmark values for toxicity to fish and benthic invertebrates.	Compare surface water COPC concentrations to AWQC (Figure 6-1).	Acute and chronic AQWC are sometimes exceeded for WAD cyanide downstream of Gold Run Creek.	+	The AWQC is based on free cyanide. HQ values based on WAD cyanide may overestimate hazard by an unknown degree.	Reject Hypothesis. Cyanide in surface water is not likely to cause effects on stockable trout, but might cause adverse effects to sensitive life stages of fish and benthic invertebrates. Other chemicals may cause intermittent low level stress.
		Occasional and generally low-level exceedences of chronic AWQC values occur for copper, lead and selenium.	+	These exceedances indicate that copper, lead and selenium in surface water could cause intermittent, low level stress.	
	Compare WAD cyanide surface water concentrations to species-specific value (Figure 6-2).	WAD cyanide concentrations exceed acute and/or chronic toxicity values for free cyanide for many fish species and some benthic invertebrate genus groups.	+	Most species-specific values are based on free cyanide. HQ values based on WAD cyanide may overestimate hazard by an unknown degree.	
	Compare surface water COPC concentrations to site-specific standards (Figure 6-3).	Site-specific standards are only rarely exceeded, and then by only a small amount.	-	Site-specific standards were developed to protect stockable size brown trout for periods of 90 days. These values might not protect more sensitive life stages of fish or some BMI.	
The concentrations of COPCs in sediment on-site are not greater than benchmark values for toxicity to benthic invertebrates.	Compare sediment COPC concentrations to toxicity benchmarks (Figure 6-5).	Predicted HQ values for sediment are generally below a level of concern for cadmium, manganese, nickel, and zinc.	-	Based on these comparisons, sediment toxicity is not predicted to be associated with these metals.	Reject Hypothesis. Sediment toxicity is predicted for Whitewood Creek sampling stations. Primary reason is elevated levels of arsenic. Other COPCs (copper, lead, mercury) might also contribute.
		HQ values for copper, lead, and mercury exceed a level of concern based on the lowest TRV but are of minimal concern based on the highest TRV.	+	Based on these comparisons, sediment toxicity from these chemicals is considered possible, but not certain.	
		Predicted HQs from arsenic are substantially above 1E+00 at all non-reference segments of Whitewood Creek and the Belle Fourche River, based on both the lower and upper toxicity benchmarks.	+	Arsenic is predicted to be associated with sediment toxicity.	
The concentrations of COPCs in sediment porewater on-site are not greater than benchmark values for toxicity to benthic invertebrates and fish.	Compare sediment porewater COPC concentrations to acute AWQC values and amphipod-specific acute TRVs	At locations where mortality was observed, concentrations of cadmium exceed acute AWQC but not amphipod acute TRV (Figure 6-6). Concentrations of arsenic exceed both benchmarks. Lead, copper and zinc exceeded the acute criteria at WWC-03, but no mortality was observed at those locations.	+	Arsenic levels could be responsible for the mortality. Cadmium might cause mortality in other receptors, but probably not <i>Hyalella</i> . Possible confounding by ammonia (see below). Porewater recovered from laboratory sediment toxicity tests may not reflect <i>in situ</i> porewater concentrations.	Reject Hypothesis. Sediment porewater could be toxic to BMI due to arsenic and possibly cadmium.

**Table 11-1. Assessment of Testable Hypotheses for Stream Function and Viability**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

Testable Hypothesis	Measurement Endpoint	Observation	Effect Score	Discussion	Conclusion
The number of taxa and individuals in the macroinvertebrate community on-site are not significantly less than numbers at reference	Compare the macroinvertebrate community (number of taxa, individuals, and other metrics) to reference communities	Whitewood Creek and Belle Fourche River benthic communities are slightly impaired relative to respective reference stations (Figure 6-9).	+	The slight impairment of the benthic community could be associated with increased metals in surface water and sediment. Levels tend to generally decrease as a function of distance downstream; proof of exposure by direct contact, sediment, and/or food web; not proof of toxicity.	Reject Hypothesis. Benthic communities in Whitewood Creek and the Belle Fourche river downgradient of the site are slightly impaired. The impairment could be related to increased metals and/or degradation of habitat quality (embeddedness) from tailings material.
		There is a reduction in the number of organisms per sample between WWC-02 upstream of Gold Run and WWC-03 downstream. The number of organisms remains small relative to reference downstream to WWC-09 (Figure 6-11).	+	There are no significant correlations between the concentrations of any of the COPCs and the individual benthic metrics or biological condition scores. An inverse association was noted for hardness.	
		Several metrics of BMI community status are correlated with habitat quality (embeddedness) (Figures 6-10 to 6-12).	-	Some of the impairment of the benthic community is likely associated with degradation of the habitat quality.	
The toxicity of COPCs in site sediment is not significantly greater than reference.	Evaluate the toxicity of site sediment to the amphipod ( <i>Hyaella azteca</i> ) (growth and survival) through laboratory testing.	The WWC-05 and WWC-06 test sediments reduced the survival of <i>H. azteca</i> . Growth of the surviving organisms was also significantly reduced in the WWC-05 sample (Table 6-10).	+	The results indicate that sediments from these locations on Whitewood Creek are toxic to aquatic invertebrates. Toxicity was not observed in other samples.	Reject Hypothesis. Sediments are toxic in some but not all locations. Arsenic, cadmium and/or mercury might be of concern at some locations, but confounding by ammonia prevents firm conclusion.
		An association was observed between mortality and concentrations of mercury in sediment and arsenic and cadmium in porewater (Table 6-11).	+	These results suggest that one or more of these metals might be responsible for the increased mortality in <i>Hyaella</i> .	
		An association was observed between mortality and concentrations of ammonia in porewater (Table 6-11).	-	The ammonia in the test chambers for WWC-05 and WWC-06 could be the cause of the observed toxicity	
	Evaluate the bioavailability of COPCs in sediment using AVS/SEM measurements.	The difference between SEM and AVS for most locations are negative (Table 6-5)	-	Based on excess AVS, sediment toxicity is not expected. Slight excesses (less than 1 umol/g) of SEM over AVS occurred at some stations, and BFR-11, but this excess is sufficiently small such that other binding agents (e.g., organic carbon) might be expected to attenuate exposures from any metals that may leach into porewater.	

**Table 11-1. Assessment of Testable Hypotheses for Stream Function and Viability**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

Testable Hypothesis	Measurement Endpoint	Observation	Effect Score	Discussion	Conclusion
The release of seep water is not significantly increasing the in-stream toxicity of surface water in WWC.	Determine the concentration of COPCs in water from seeps and compare to AWQC.	Most COPCs are below a level of concern even in the undiluted seep water. However, arsenic levels in seep water are often above the acute and/or chronic AWQC value, and aluminum and lead are above the chronic AWQC value in two locations (Table 6-12).	+	Undiluted seep water may be toxic to aquatic receptors. However, direct contact with undiluted seep water is not expected.	Accept Hypothesis. Under the conditions measured, the seeps are not expected to be toxic to freshwater fish and benthic invertebrates.
		Concentrations of COPCs in surface water downstream of seeps are often elevated compared to the upstream location. However, none of the elevations result in an exceedence of the acute or chronic AWQC values.	-	Seeps may be contributing to the metals load in the river, but because of dilution in the stream, seep releases are not likely to be a source of significant toxicity in surface water.	
	Evaluate the acute toxicity of seep water to the fathead minnow ( <i>Pimephales promelas</i> ) through laboratory testing.	The site-specific seep water samples are not acutely toxic to the fathead minnow after 96 hours of exposure in laboratory testing in any of the 5 seep water samples compared to reference (Table 6-14).	-	Fathead minnow may not be as sensitive as other species that reside in Whitewood Creek. Potential effects of chronic exposure are not evaluated by this test.	
The concentrations of COPCs in benthic invertebrates and sediment on-site are not greater than toxicity benchmark values for ingestion by fish.	Compare concentrations of COPCs in benthic invertebrate tissues to toxicity benchmarks for ingestion by fish.	HQ values do not exceed a value of 1E+00 for cadmium, copper, lead, or zinc, but do occasionally exceed a value of 1E+00 for arsenic (Table 6-6).	+	Most of the exceedences are based on the NOAEL-based TRV. Risks based on the LOAEL-TRV are mainly below a level of potential concern.	Accept Hypothesis. Adverse effects to fish resulting from ingestion of COPCs in food and sediment are not likely.
	Compare concentrations of COPCs in sediment to toxicity benchmarks for fish ingestion.	Concentrations of all COPCs in sediments at all stations are less than respective NOAEL-based and LOAEL-based toxicity benchmarks (Table 6-7).	-	Sediment intakes by fish are uncertain. Based on assumed intake rates, the ingestion of these metals in sediment is not predicted to cause adverse effects to fish.	
The concentrations of COPCs in fish tissue on-site are not greater than toxicity benchmark values for fish tissue.	Compare the concentrations of COPCs in fish tissue to toxicity benchmarks for fish tissue.	HQ values are consistently above 1E+00 for mercury and zinc (Table 6-9).	o	HQ values tend to be elevated for mercury and zinc at the reference locations as well as the site stations, suggesting the MATC values for these chemicals may be somewhat too low.	Accept Hypothesis. Data are too limited to support firm conclusion, but results suggest most fish do not have tissue burdens that are likely to be associated with toxicity.
		HQ values for arsenic exceed 1E+00 in a few samples of fish from the upper reaches of Whitewood Creek (Table 6-9).	+	Arsenic might be of concern to some individual fish but probably not all fish (the average HQ for arsenic for all fish excluding reference locations is 6E-01). Data are too limited and the values too variable to draw a firm conclusion	

**Table 11-2. Weight of Evidence Evaluation for Stream Function and Viability**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

Medium	Assessment Method	Conclusions	Weight of Evidence for Medium	Weight of Evidence for Ecosystem
Surface water	Predictive (HQ and HI approach)	Cyanide in surface water is not likely to cause effects on stockable trout, but might cause adverse effects to sensitive life stages of fish and benthic invertebrates. Other chemicals may cause intermittent low level stress.	Risks to fish and BMI from cyanide are possible, but magnitude is unknown. Impacts from other COPCs in surface water are likely low and intermittent.	Some effects of COPCs on stream viability and function may be occurring, but the impacts are sufficiently low that community and population level effects are not readily apparent.
	Site-specific toxicity testing	No toxicity observed for fathead minnows in water from 5 locations above and below seeps along Whitewood Creek.		
Sediment and porewater	Predictive (HQ and HI approach)	Sediment toxicity is predicted for BMI in Whitewood Creek sampling stations. Primary reason is elevated levels of arsenic. Other COPCs (copper, lead, mercury) might also contribute.	Risks to BMI are possible, but impacts from COPCs in sediment are likely to be restricted to a small number of locations.	
	Site-specific toxicity testing	Risks to BMI from sediments are low at most locations. Arsenic, cadmium and/or mercury might be of concern at some locations, but confounding by ammonia prevents firm conclusion.		
Seep water	Predictive (HQ and HI approach)	Undiluted seep water may be toxic to aquatic receptors. However, after dilution, risks are not predicted.	Risks from seep water are not of concern.	
	Site-specific toxicity Testing	Seep water samples are not acutely toxic to the fathead minnow.		
Diet	Predictive (HQ and HI approach)	Adverse effects to fish resulting from ingestion of COPCs in food and sediment are not likely.	Risks to fish from ingestion of aquatic prey items or sediment are not of concern.	
	Site-specific toxicity testing	No data		
All	Site-specific population observations	Tissue levels of arsenic exceed MATC in some fish, but average is below a level of concern. Population density and diversity of fish, BMI and periphyton are generally similar to other streams, and do not appear to be correlated with COPC levels.	Population level effects are not apparent.	

**Table 11-3. Assessment of Testable Hypotheses for Riparian Floodplain Function and Viability**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

Testable Hypothesis	Measurement Endpoint	Observation	Effect Score	Discussion	Conclusion
The concentration of COPCs in on-site riparian floodplain soils is not greater than phytotoxicity benchmark values (The on-site riparian habitat is not significantly degraded relative to the reference)	Compare the distribution of surface soil COPC concentrations to plant toxicity benchmarks (Figure 7-1).	For antimony, barium, copper, lead, mercury, molybdenum, nickel, silver, thallium, and zinc, most or all calculated HQs are below a level of concern.	-	These metals are not predicted to be associated with phytotoxicity.	Reject Hypothesis. Arsenic and perhaps manganese in site soils is predicted to be associated with phytotoxicity.
		HQs for aluminum, boron, chromium, and vanadium are greater than 1E+00 at all stations, including each of the reference locations.	0	This indicates that the phytotoxicity benchmark values for these chemicals are probably not appropriate for soil conditions in the Whitewood Creek study area and may over-predict risks.	
		For arsenic, HQ values are above a level of concern at all site locations, but are below a level of concern at all reference stations. Manganese is similar, but HQ values are lower.	+	Benchmarks are not site-specific and may not account for site-specific factors.	
The concentration of COPCs in on-site riparian floodplain soils is not greater than soil invertebrate benchmark values (The on-site riparian habitat is not significantly degraded relative to the reference)	Compare the distribution of surface soil COPC concentrations to soil invertebrate toxicity benchmarks (Figure 7-2).	HQ values are at or below a level of concern for barium, boron, copper, lead, mercury, molybdenum, nickel, silver, vanadium, and zinc.	--	These metals are not predicted to be associated with toxicity to soil invertebrates.	Reject Hypothesis. Arsenic in site soils is predicted to be associated with toxicity to soil invertebrates.
		HQs for aluminum, iron, and manganese are greater than 1E+00 at all locations, but the values at reference locations are generally similar to the site locations. A generally similar pattern is observed for chromium, although the HQ exceedences are lower.	0	Benchmark values for these chemicals may over predict risks and may not reflect soil conditions in the Whitewood Creek study area.	
		Arsenic HQs are above a level of concern at all site locations, and are below a level of concern at all reference locations.	+	Benchmark for arsenic is are not site-specific and may not account for site-specific factors.	
The concentration of COPCs in on-site seep water is not greater than phytotoxicity benchmark values (The on-site riparian habitat is not significantly degraded relative to the reference)	Compare seep water COPC concentrations (mean at sampling station) to plant toxicity benchmarks for solution exposures	All reported seep water concentrations of cadmium, copper, lead, mercury, nickel, selenium and zinc are lower than respective toxicity benchmarks.	-	Risk of phytotoxicity from these chemicals is not expected.	Reject Hypothesis. If plant roots are exposed to seep water, phytotoxicity from root exposure to arsenic could be occurring.
		Arsenic in seep water exceeds the screening benchmark at all sampling locations except the reference station.	+	Seep water may not be representative of soil water in the root zone. There is low confidence in the screening benchmark.	

**Table 11-3. Assessment of Testable Hypotheses for Riparian Floodplain Function and Viability**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

Testable Hypothesis	Measurement Endpoint	Observation	Effect Score	Discussion	Conclusion
The toxicity of riparian floodplain soils is not significantly greater than reference.	Evaluate the toxicity of COPCs from soil through solid-phase testing using earthworms. (Table 7-5).	None of the earthworms survived at WWC-05. This response is statistically significant ( $p < 0.05$ ) compared to all reference soils.	++	Soils from other site locations did not cause mortality. This location or sample may be un-representative.	Accept Hypothesis. Site soils are not generally toxic to plants or soil invertebrates.
		Mean length and mean weight were not significantly different in worms exposed to WWC site soils compared to laboratory control soil or WWC reference soil. Compared to Spearfish Creek soil, there was a decrease in length for worms exposed for 14 days (but not 28 days) to soil from WWC-07, and an increase in weight loss for worms from WWC-08 and WWC-09.	-	There is no clear spatial pattern of toxicity and no apparent meaningful associations between any of the earthworm toxicity measurement endpoints and any of the COPCs in soil. This suggests that COPCs in site soil are probably not responsible for the observed earthworm toxicity.	
		The responses measured in the testing (mortality and growth parameters) could not be correlated with the concentration of the COPCs or other measured soil parameters.	-		
	Evaluate the toxicity of COPCs in soil through laboratory toxicity testing using plants.	Nearly all of the growth responses for rye grass seeds were not significantly lower than for seeds grown in soil from Whitewood Creek reference soil or laboratory control soil.	-	Based on the finding that growth of ryegrass in Whitewood Creek soils downstream from Gold Run Creek is not lower than for soil from a reference area upstream of Gold Run Creek and is also generally similar to laboratory control soil, and that no clear correlation between phytotoxicity and soil concentration of any COPC could be detected, it is concluded that riparian floodplain soils along Whitewood Creek are not significantly phytotoxic to plants.	
		Nearly all of the growth responses for seeds grown in WWC soils were significantly lower than for seeds grown in soil from Spearfish Creek.	+		
		No clear association was detected between soil levels of COPCs and measures of phytotoxicity.	-		
The number of vascular plant taxa and on-site are not significantly less than the numbers at reference.	Compare the vascular plant community-types present on-site to reference (Table 7-10)	Based on the Spearfish Creek site (18 total species), Whitewood Creek station WWC-05 is judged to be similar (21 species), while sites WWC-06 and WWC-08 are somewhat less diverse (10 species).	-	The plant data are qualitative in nature and do not support quantitative, statistical comparisons to reference.	Data are insufficient to support quantitative conclusion.
The soil community on-site is not different from that at reference locations.	Compare the soil function parameters on-site to reference.	Variability in many parameters is apparent as a function of location.	na	Information regarding interpretation of measured soil function parameters is not available; no comparison was performed.	Knowledge is insufficient to support a conclusion.

**Table 11-4. Weight of Evidence Evaluation for Riparian Floodplain Function and Viability**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

Medium	Assessment Method	Conclusions	Weight of Evidence for Medium	Weight of Evidence for Ecosystem
Site Soil	Predictive (HQ and HI approach)	Arsenic and perhaps manganese in site soils is predicted to be associated with phytotoxicity. Arsenic in site soils is predicted to be associated with toxicity to soil invertebrates.	Site soils are not generally toxic to plants or soil invertebrates.	Some effects of COPCs on riparian zone viability and function may be occurring, but the impacts are sufficiently low that community and population level effects are not readily apparent.
	Site-specific toxicity testing	Site soils are not generally toxic to plants or soil invertebrates.		
Seep water	Predictive (HQ and HI approach)	If plant roots are exposed to seep water, phytotoxicity from root exposure to arsenic could be occurring. Confidence in TRV is low.	If plant roots are exposed to seep water, phytotoxicity from root exposure to arsenic could be occurring, but confidence is low.	
	Site-specific toxicity Testing	No data		
All	Site-specific population observations	Plant population data are insufficient to support quantitative conclusion. Knowledge is insufficient to interpret soil microinvertebrate study .	Plant and microinvertebrate population data are insufficient to support a firm conclusion	

**Table 11-5. Assessment of Testable Hypotheses for Wildlife Viability**

***Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota***

Testable Hypothesis	Measurement Endpoint	Observation	Effect Score	Discussion	Conclusion
The ingestion exposure of surrogate wildlife species to COPCs in on-site media (water, food, soil, sediment) is not greater than toxicity reference values.	Based on measured concentrations in site media, calculate doses of each COPC from each medium for each surrogate species and compare to respective toxicity reference value. Sum HQ results across pathways to estimate HI for each COPC. Compare results for on-site and reference (Appendix L).	For the great horned owl and the American dipper, predicted HI values do not exceed a level of concern for any COPC at any location.	-	No evidence of concern for these species.	Reject Hypothesis. Risks may be occurring to terrestrial wildlife species from incidental ingestion of arsenic in soil or sediment. Risks from food web exposure do not appear to be significant.
		Several COPCs (including aluminum, antimony, barium lead, manganese, molybdenum, thallium, and vanadium) are predicted to cause HI values above 1E+00 for one or more receptors, but in all cases the HI value exceeds a value of 1E+00 in one or more reference areas as well as site areas.	0	Occurrence of HI values above 1E+00 for reference areas suggests that the TRVs and/or the RBA values for these COPCs may be too conservative, since toxicity is not expected to be significant in reference areas. Thus, these HI values should be not be interpreted as strong evidence of potential harm.	
		Arsenic is predicted to cause HI values well above 1E+00 for a majority of receptors in most site exposure zones, but not in any reference zones. These elevated HI values are due almost entirely to ingestion of soil or sediment while feeding, with relatively little contribution from water or food web items.	+	Arsenic in soil or sediment might pose a health risk to a majority of wildlife receptors, including representatives of nearly all feeding guilds.	
The ingestion exposure of wildlife species to COPCs in on-site seep water is not greater than toxicity reference values.	Estimate the daily dose of each COPC for each surrogate species for ingestion of seep water and compare to respective toxicity reference value. Compare results for on-site and reference.	All HQ values for each COPC for each seep are less than or equal to one (Appendix L).	-	Seep water samples that have been collected may not represent all conditions.	Accept Hypothesis. Ingestion of COPCs in seep water is not likely to be of concern to wildlife receptors.
The body burden of COPCs in selected species on-site is not greater than reference.	Determine body burdens of COPCs in small mammals and birds on-site and compare to reference	Qualitative comparison of tissue burdens in tissues of small mammals does not reveal any clear differences for any COPC except arsenic (Appendix M).	-	COPCs other than arsenic are not likely to be of concern to small mammals.	Reject Hypothesis. Increased exposure of small mammals is occurring for arsenic.
		Concentrations of arsenic are higher in tissues from small mammals collected on site than for reference areas (Figure 8-2). Arsenic is also higher in most tissue and diet samples for birds.	+	The increased concentrations in on-site areas documents increased exposure but not necessarily increased adverse effects.	

**Table 11-5. Assessment of Testable Hypotheses for Wildlife Viability**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

Testable Hypothesis	Measurement Endpoint	Observation	Effect Score	Discussion	Conclusion
The histopathology of organ tissues in selected species on-site is not significantly different from reference.	Determine the weights of liver, kidney and spleen in small mammals on-site and compare to reference (Figure 8-3)	There is no clear difference in relative liver weights or relative kidney weights in small mammals collected from White Creek sites compared to reference sites.	-	These data do not indicate that COPC exposure is causing observable dysfunction in liver or kidney of small mammals. However, some adverse effects are not readily detected by routine gross or microscopic examination.	Accept Hypothesis. Available data do not indicate that COPCs are associated with significant pathology in small mammals.
		There is a tendency for relative spleen weights to be higher in animals from Whitewood Creek sites than reference locations.	o	The increase in spleen weight could not be correlated with concentrations of any COPC measured in tissue. The cause or significance of this observed effect is unknown.	
	Examine the liver, kidney and spleen in small mammals on-site for histological abnormalities and compare to reference (Table 8-8).	Apparent increased incidence of abnormal findings in animals from on-site compared to reference. Effects are not consistent across tissues or locations.	+	Lack of consistency decrease confidence that the effects are COPC related.	

**Table 11-6. Weight of Evidence Evaluation for Wildlife Viability**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

Medium	Assessment Method	Conclusions	Weight of Evidence for Medium	Weight of Evidence for Ecosystem
Surface water	Predictive (HQ and HI approach)	Predicted HQ values for ingestion of surface water are not of concern.	Risks to wildlife from surface water are not of concern.	Some effects of COPCs on terrestrial wildlife may be occurring, mainly from ingestion of arsenic. However, impacts are not certain and are probably sufficiently low that community and population level effects are not substantial.
	Site-specific toxicity testing	No data		
Soil and Sediment	Predictive (HQ and HI approach)	Predicted HQ values for ingestion of arsenic in soil or sediment are of concern in most locations for most receptors.	Risks to wildlife from arsenic in soil or sediment may be of concern.	
	Site-specific toxicity testing	No data		
Seep water	Predictive (HQ and HI approach)	Predicted HQ values for ingestion of seep water are not of concern.	Risks to wildlife from seep water are not of concern.	
	Site-specific toxicity Testing	No data		
Diet	Predictive (HQ and HI approach)	Predicted HQ values for ingestion of terrestrial prey items are not of concern.	Risks to wildlife from terrestrial prey items are not of concern.	
	Site-specific toxicity testing	No data		
All	Site-specific population observations	Available data do not indicate that COPCs are associated with significant pathology in small mammals.	Data do not reveal evidence of adverse effects, but ability to detect effects may be low.	
		Populations of birds and mammals are present, but data do not allow determination if levels are lower than expected.		

**Table 11-7. Assessment of Testable Hypotheses for Amphibian Viability**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

Testable Hypothesis	Measurement Endpoint	Observation	Effect Score	Discussion	Conclusion
The concentrations of COPCs in surface water are not greater than toxicity benchmarks for amphibians.	Compare the distribution of surface water COPC concentrations to amphibian toxicity benchmarks (Figure 9-1)	Concentration values of dissolved aluminum in surface water in Whitewood Creek might occasionally reach a level of concern for the Eastern narrow-mouthed toad. Other amphibian species for which toxicity data exist are not at risk from dissolved aluminum.	-	Because the concentration of aluminum shows little spatial pattern, aluminum concentrations are probably not substantially increased by mine-related releases.	Reject Hypothesis. Risks to amphibians from silver in surface water are possible in the upper portion of WWC. Other chemicals in surface water are not likely to be of concern, and seep water is not of concern.
		Concentrations of dissolved copper, lead, and selenium do not exceed a level of concern based for any of the amphibian species for which toxicity data are available.	-	Data do not suggest concern for amphibians for these metals.	
		Concentrations of dissolved silver reach or exceed a level of concern for two amphibian species (Eastern narrow-mouthed toad, common Indian toad) in the upper reaches of Whitewood Creek, but not at stations below the Berger Seep.	+	Silver in the upper reach might be of concern to some amphibian species.	
	Compare seep water COPC concentrations to amphibian toxicity benchmarks (Figure 9-2)	With the exception of a few data points for aluminum and one data point for lead, concentrations of COPCs in seep water are below a level of concern for all of the amphibian species for which TRVs could be located.	-	Data do not suggest concern for amphibians at seeps.	
The toxicity of COPCs in Site sediment is not significantly greater than at the reference.	na	na	o	No sediment toxicity benchmarks were located for amphibians. Risks from sediment contact is likely to be small compared to risks from contact with water.	Accept Hypothesis. Since risks from water appear to be generally low, risks from sediment are likely to be below a level of concern.

**Table 11-8. Weight of Evidence Evaluation for Amphibian Viability**

*Ecological Risk Assessment  
Whitewood Creek Site, Lead, South Dakota*

Medium	Assessment Method	Conclusions	Weight of Evidence for Medium	Weight of Evidence for Ecosystem
Surface water	Predictive (HQ and HI approach)	Risks to amphibians from silver in surface water are possible in the upper portion of WWC. Other chemicals in surface water are not likely to be of concern.	Potential risks exist in upper reaches of WWC.	Although some effects are possible for some receptors, overall hazard does not appear to be substantial.
	Site-specific toxicity testing	No data		
Sediment	Predictive (HQ and HI approach)	Risks from sediment are likely to be below a level of concern.	Data are sparse, but effects are not expected.	
	Site-specific toxicity testing	No data		
Seep water	Predictive (HQ and HI approach)	Seep water is not of concern.	Effects are not expected.	
	Site-specific toxicity Testing	No data		
Diet	Predictive (HQ and HI approach)	No data	No data, but effects are likely to be low.	
	Site-specific toxicity testing	No data		
All	Site-specific population observations	No data	No data	

**-FINAL-  
ECOLOGICAL RISK ASSESSMENT  
WHITEWOOD CREEK SITE FIVE YEAR REVIEW  
LEAD, SOUTH DAKOTA**

**July 2002**

**Appendices A to M**

## **APPENDIX A**

### **SUMMARIES OF KEY INVESTIGATIONS, STUDIES, AND REGULATORY DOCUMENTS**

## **Studies Used as the Basis of the Whitewood Creek ROD**

The following studies were used as the basis for the Whitewood Creek ROD:

***Whitewood Creek Study, Phase I (Fox Consultants, Inc., 1984a).*** In 1982, The South Dakota Department of Water and Natural Resources (SDDWNR) (now the Department of Environment and Natural Resources (SDDENR)) and HMC entered into a three-part agreement to complete a comprehensive study of the Whitewood Creek Superfund Site. The study was completed by Fox Consultants, Inc. (Denver, Colorado), funded by HMC and supervised by a project advisory committee. The study investigated the quality of surface waters, groundwater, soil, sediments and vegetation in the study area and selected aquatic life (ICF, 1989a). The findings of the study were issued in a multi-volume report completed in December of 1994 (Fox Consultants, Inc., 1984a and 1984b).

Phase I of the Whitewood Creek Study describes target substances, tailings, the existing environment of the study area and sample preparation and analysis procedures to be used for the remaining study phases. Analytical data available from the Phase I Study report that is used for the ERA includes:

- Metal content in Site vegetation, and soils from irrigated croplands and native vegetation areas
- Metal content in Site aquatic benthic invertebrates and fish
- Metal content in Site surface water and sediments
- Background metal content in soils, benthic invertebrates, surface water, sediments and fish

This analytical data was, however, collected prior to the installation of the wastewater treatment plant near Lead in 1984. This data (with the exception of background) may not be indicative of current metal concentrations in Site media.

General site characterization data and biological data from the Phase I Study report includes:

- Descriptions of tailings and the environment within the study area
- Descriptions of the vegetative cover within the Whitewood Creek and Belle Fourche River floodplains
- Qualitative description of the fish community
- Qualitative description of the benthic invertebrate community
- Quantitative sampling of the benthic invertebrate community
- Qualitative description of the periphyton community

***Whitewood Creek Study, Phase II (Fox Consultants, Inc., 1984b).*** The Phase II Whitewood Creek Study presents the results of analyses and interpretation of data presented in Phase I. The study evaluates vadose zone, groundwater, surface water, soil, irrigated crop, native vegetation, fish and invertebrate analytical data. Fourteen target substances were identified for evaluation. The report presents an interpretation of the significance of target substance concentrations in each media and an assessment of the impacts they pose to public health, welfare and the environment.

***Bioassessment of Whitewood Creek Lawrence and Mead Counties, South Dakota. (Herrick, 1982).*** This study is cited in Fox Consultants (1984a) and the EA (USEPA, 1989a). The environmental survey of aquatic resources and ecological conditions completed by Herricks (1982) established twelve stations on Whitewood Creek that were sampled for fish, invertebrates and algae. Four of these stations (WW-10,

WW-01A, WW-01B and WW-02) occur within the present Whitewood Creek study area.

***Assessment of Exposure and Possible Effects on Human Health of Gold Mine Tailings in the Whitewood Creek Area of South Dakota (Environ, 1985).*** An endangerment assessment was prepared by Environ, Inc. on behalf of HMC in 1985. This study evaluated possible adverse effects on human health associated with gold mine tailings in Whitewood Creek. The assessment used data from the Phase I Whitewood Creek Study and the USGS surface water investigations (USGS, 1985). This study evaluated the findings of the Phase II Whitewood Creek Study and primarily pertains to human health risks.

***An Evaluation of Aquatic Life Impacts Presented in the Draft Battelle Whitewood Creek Endangerment Assessment (Industrial Waste Management, Ltd., 1988).*** The purpose of this report was to review the conclusions of the Phase II Whitewood Creek Study pertaining to aquatic life and to provide technical comments to aid Battelle in preparation of the final endangerment assessment for EPA (USEPA, 1989a). The study includes a statistical evaluation of water quality sampling results before and after the installation and operation of the wastewater treatment system by HMC. This study compared water quality data (collected after installation) with relevant and appropriate water quality criteria for aquatic life. The study was completed by Dr. Terry I. Mudder of Industrial Waste Management, Ltd.

***Aging of Tailings Deposits by Tree Ring Analysis (Batt, 1988).*** A study of the age of trees was completed with the goal of aging the deposits of tailings along Whitewood Creek. Tree ring analysis was completed at seven sites along Whitewood Creek. The information provides the age of trees in tailings along Whitewood Creek but does not provide information on the "health" of the vegetative community nor the stability of the tailings deposits near the creek.

***Selenium Sources, Occurrences, and Mobility along Whitewood Creek, South Dakota (Geochemical Engineering Incorporated, 1988).*** This report was prepared on behalf of HMC. The report describes the geochemistry of selenium, typical media selenium concentrations, and selenium occurrence in the Whitewood Creek Area.

***Endangerment Assessment for the Whitewood Creek Superfund Site, Southwestern South Dakota Volumes 1 and 2 Final Review Draft (USEPA, 1989a).*** The Whitewood Creek Preliminary Endangerment Assessment was completed by Battelle Pacific Northwest Laboratory (PNL) for the EPA Office of Health and Environmental Assessment. The assessment is reported in two volumes with Volume 1 containing the discussion and conclusions and Volume 2 containing supporting appendices.

***Final Endangerment Assessment Summary Document for Whitewood Creek Superfund Site (Jacobs Engineering, 1989).*** The EA for the Whitewood Creek Site was finalized by Jacobs Engineering Group Inc. as a contractor to EPA Region VIII in July 1989. The final EA was based on information in USEPA (1989a) and Subsection 1.7 of the Preliminary Draft of the FS prepared by ICF Technology in April of 1989. The separated document Subsection 1.7 constitutes the baseline assessment of potential health impacts for the FS.

***Impact of High Flow Events on the Potential for Exceedance of Aquatic Life Criteria for Arsenic (Mudder, 1989).*** This memo report was written by T.I. Mudder of Steffen Robertson and Kersten Consulting Engineers on behalf of HMC. The memo was written to respond to concerns for the potential impacts of arsenic in surface water. These concerns were raised in the preliminary EA completed by Battelle on behalf of EPA (USEPA, 1989a).

***Composition, Distribution and Hydrologic Effects of Contaminated Sediments Resulting from the Discharge of Gold Milling Wastes to Whitewood Creek at Lead and Deadwood, South Dakota (USGS, 1989).*** This report replaces a draft report referred to as USGS (1985) or Goddard (1985) entitled Composition, Distribution, and Hydrologic Effects of Mine and Mill Wastes Discharged to Whitewood Creek at Lead/Deadwood, South Dakota. The mineral composition and chemical characteristics of contaminated-sediment samples collected from the flood plains along Whitewood Creek and the Belle Fourche River are evaluated. The "sediment" samples referred to are not bottom sediments within Whitewood Creek but are instead floodplain soils.

## **Studies Completed After the Whitewood Creek ROD**

***Arsenic Concentrations of Selected Benthic Insects in Whitewood Creek and the Belle Fourche River, South Dakota. USGS (1988c).*** This study was reported at a symposium held in Denver, Colorado in 1988. The data presented at the Denver symposium is basically the same data as reported in Cain et al. (1988a) from a symposium held in Phoenix, Arizona. Additional data regarding relative abundance of benthic species from the study area locations is presented in this report. Benthic invertebrates were collected from ten stations with two stations being outside (upstream) of the study area. The samples were collected in June and August of 1986.

***Temporal and Spatial Variability of Arsenic in Benthic Insects from Whitewood Creek, South Dakota (USGS, 1988d).*** This study presents the measurements of whole body arsenic concentrations in benthic invertebrates collected from seven stations on Whitewood Creek and the Belle Fourche River. The sampling stations included four of the same sampled in 1986 as reported in Cain et al. (1988a) and three new stations. Sediment samples were collected concurrently and analyzed for arsenic content. Arsenic concentrations in benthic invertebrates measured in 1987 were generally similar to those measured in 1986. Arsenic concentrations in three benthic invertebrate species (*Choroterpes* sp., *Tricorythodes* sp., and *Ambrysus* sp.) collected within the plume of a seep were elevated in comparison to concentrations measured 100 meters upstream at a separate station. The arsenic concentration in benthic invertebrates reflected differences between unenriched and contaminated streambed sediments in Whitewood Creek. Body size and trophic level influenced the arsenic concentrations in taxa. There was also evidence of species specific differences in arsenic accumulation.

***Aquatic Biological Survey of Whitewood Creek and the Belle Fourche River, South Dakota (Chadwick & Associates, 1990a).*** Periphyton, benthic invertebrate and fish communities were quantitatively sampled from 6 locations on Whitewood Creek and the Belle Fourche River in June 1989. Whole body forage, rough and game fish tissue samples were collected and analyzed for arsenic, lead, mercury, selenium and zinc. These studies were completed at the time the ROD was being finalized. The information is not used in the EA (USEPA, 1989a; Jacobs Engineering, 1989) nor in the ROD (USEPA, 1990).

***Aquatic Biological Survey of Whitewood Creek and the Belle Fourche River, South Dakota, September 1990. (Chadwick & Associates, 1990b).*** Periphyton, benthic invertebrate and fish communities were quantitatively sampled from 6 locations in April 1990. These studies were completed during the time the ROD was being finalized. The information was neither used in the EA (USEPA, 1989a; Jacobs Engineering, 1989) nor in the ROD (USEPA, 1990a).

***Wildlife Survey of Whitewood Creek in Lawrence, Meade and Butte Counties, South Dakota (Harner & Associates, Inc., 1990a).*** This report provides the results of wildlife surveys conducted in May and June of 1989 for big game, upland game birds, raptors, breeding birds and small mammals. The study area for the surveys encompasses most of the Site and is bounded on the north by the Belle Fourche River and on the south by Interstate 90. The eastern and western extents of the study area are within one half mile of Whitewood Creek. This information on wildlife was collected in the vicinity of a proposed removal operation of tailings and was gathered to fulfill requirements of a mining permit application. Whitewood Development Corporation proposed the removal and processing of tailings deposited adjacent to Whitewood Creek.

***Second Year Baseline Wildlife Survey of Whitewood Creek in Lawrence, Meade and Butte Counties, South Dakota. (Harner & Associates, Inc., 1990b).*** This report presents the results of a second year of baseline wildlife studies for Whitewood Creek. These studies continue the inventory and monitoring programs for wildlife that began in 1989 (Harner & Associates, Inc., 1990a).

***Chadwick Ecological Consultants, Inc. (1996).*** This study is cited in the Status Report and Technical Support Document for the 1997 5-Year Review (Chadwick Ecological Consultants, Inc. et al., 1997) and the raw data remain unpublished. Periphyton, benthic invertebrate and fish communities were quantitatively sampled in 1996 from six sites in Whitewood Creek and 2 sites in the Belle Fourche River) including two reference sites. Whole-body forage, rough and game fish tissue samples were collected and were analyzed for five metals (As, Pb, Hg, Se, and Zn).

***Whitewood Creek Biological Survey Summary (Knowles, 1996a).*** This report was prepared for the Whitewood Creek Development Corporation in January of 1996 in support of partial fulfillment of a mining permit application. This study reports the results of wildlife surveys of the same areas for the same wildlife species as the those completed in 1989 and 1990 (Harner & Associates 1990a and 1990b). The wildlife studies included specific surveys for raptors, upland game birds, wintering and breeding birds, deer and small mammals. This report includes information on threatened and endangered species within the study area.

***Whitewood Creek Biological Survey Summaries 1996 Breeding Bird Survey Narrative (Knowles, 1996b).*** This report provides the results of a survey of breeding birds at 82 observation stations established in riparian habitat along Whitewood Creek and 17 observation stations in a grassland habitat adjacent to Whitewood Creek. The information was collected in May and July of 1996 in support of a mining permit for tailings removal and a tailings processing site.

***Final Status Report and Technical Support Document for the 1997 5-Year Review (Chadwick Ecological Consultants, Inc. et al., 1997).*** This document was written to support the 5-year review of the ROD for the Whitewood Creek Superfund Site. The document contains data on the aquatic biology of Whitewood Creek (periphyton, benthic invertebrates and fish) and provides a review of surface water quality.

## **Nature and Extent of Ecological Risks Described in Previous Studies**

### **1984 - Whitewood Creek Study Phase II**

Fox Consultants examined the data collected in the *Phase I Study* (Fox Consultants, Inc., 1984a) and evaluated the impacts of fourteen Target Substances including arsenic, cadmium, iron, lead, chromium, manganese, mercury, zinc, sulfate, selenium, copper, cyanide, silver and nickel in environmental medium. The environmental media examined included vadose zone water, groundwater, surface water, soil, irrigated crops (IC), natural vegetation (NV), fish and aquatic invertebrates. Each Target Substance in each medium was classified as:

#### **Environmental threat (ET)**

Target substances that have been documented at concentrations measured in the Study Area to cause adverse public health effects and/or toxic effects on vegetation, wildlife, livestock, and aquatic life.

#### **Environmental concern (EC)**

Target substances in this category are distinguished from the Environmental Threat category by the lack of documented cause and effect relationships. Substances in this category had to possess two key characteristics. First, sample concentrations either had to frequently equal or exceed criteria or standards established to protect organisms or potential consumers of the organism from toxic effects, or, where established criteria are unavailable, concentrations had to consistently meet or exceed levels generally reported in literature associated with lethal or sublethal effects. Second, a sufficient number of sample data points had to be available to indicate that a clear trend of excessive concentrations was present.

#### **Possible environmental concern (PC)**

Target substances well recognized as having moderate to high potential for causing adverse environmental effects, but for one or more reasons could not be readily assigned to either one of the other three categories. Reasons could include: (1) availability of only a very limited number of sample results with one or two approaching or exceeding reported acceptable concentrations; (2) resolution of probable environmental hazard was dependant on biological, physical, and/or chemical data not collected in Phase 1; and (3) inadequate or contradictory literature references were present making a reasonable determination of the significance of the sample concentrations difficult. In addition, substances may exceed aesthetic criteria but not have any sublethal implications. The existing sample data and available reference data suggested that potential environmental hazards may be present, but for one or more reasons, the significance of the potential concern could not be determined using the existing data base.

#### **No environmental concern (NC)**

Substances in this category were judged to present little, if any, environmental concern based on the concentrations detected in the study area samples and the relative toxicity of the substance. Target substances were considered to be of no environmental concern if sample concentrations

from the contaminated areas were: (1) not reported in detectable concentrations in any of the samples; (2) equivalent to the typical range of concentrations commonly reported in the literature for natural uncontaminated areas; or (3) well below any criteria or standards, action levels, or concentration ranges reported in the literature as causing adverse biological or environmental effects.

This scoring system was applied to analytical data for the vadose zone (soil lysimeter data), groundwater, surface water, soils, irrigated crops, native vegetation, fish and invertebrates with the following results:

Summary of Target Substance Impact Scoring									
	Vadose Zone	Ground water	Surface Water	Soils IC	Soils NV	IC	NV	Fish	Aquatic Inverts
Arsenic	EC	EC	EC	PC	EC	PC	EC	NC	PC
Cadmium	PC	NC	EC	PC	PC	PC	NC	NC	NC
Copper	NC	NC	EC	PC	PC	PC	PC	NC	NC
Chromium	PC	NC	PC	NC	NC	NC	NC	NC	NC
Cyanide	NE	NC	EC	NE	NE	NE	NE	NE	NE
Iron	PC	NC	NC	NC	NC	NC	NC	NC	NC
Lead	PC	NC	PC	NC	NC	NC	NC	NC	NC
Manganese	PC	NC	NC	NC	PC	NC	NC	NC	NC
Mercury	NC	NC	PC	NC	NC	NC	NC	NC	NC
Nickel	PC	NC	NC	NC	NC	NC	NC	NC	NC
Selenium	PC	EC	PC	NC	NC	NC	NC	NC	NC
Silver	NC	NC	PC	NC	NC	NC	NC	NC	NC
Sulfate	NE	EC	PC	NC	PC	NE	NE	NE	NE
Zinc	NC	NC	PC	NC	NC	NC	NC	NC	NC
ET = Environmental Threat EC = Environmental Concern PC = Possible Concern NC = No Concern NE = Not Evaluated									

The evaluation of the environmental media consisted of the following:

- Vadose zone (exposure of plants to vadose zone water) water concentrations of target substance was compared to concentrations associated with toxic effects to terrestrial plants. This evaluation was not completed for cyanide, iron, selenium, silver, or sulfate. The toxic effect concentrations were presented as a range and were compared to a range of exposure concentrations. The source of the effect concentrations is unknown.
- Surface water concentrations were compared to ambient water quality criteria (chronic). Concentrations of mercury, copper, cyanide, silver, zinc and lead exceeded criteria. Some were classified as possible concern and others as environmental concern.
- Soil concentrations of target substances in both native vegetation areas and irrigated croplands were compared to the “upper limits” of each target substance from the sludge land application rules (USEPA, 1983).

- Fish and aquatic invertebrate tissue concentrations were evaluated based on comparison of the tissue concentrations with tissue burdens from undegraded and from “unknown or somewhat degraded” waters.

The classification of Target Substances into the categories was very subjective, as there were no quantitative measures for the rules used to place substances within the specific categories. Also absence of information often resulted in placement of the target substance in the category of “no concern”. For example, if criteria or benchmarks were unavailable for comparisons, the Target Substance were placed, in some cases, in the no concern category. The interpretation of the “Environmental Threat” category was rigorous (no target substances fell within this category) and appeared to include only substances that have been absolutely demonstrated to cause adverse effects within the Study Area. Yet this was the first investigation of the site area and the data to substantiate demonstrated adverse effects had not been attempted. There is also some conflict over the definition of this category as the executive summary interprets “environmental threat” as target substances “requiring immediate remedial action”.

The evaluation of each medium did not consider the potential fate and transport of constituents from the source (tailings) to ecological receptors and the specific probable exposure pathways for each receptor. For example, some of the omissions include the evaluation of:

- Exposures for fish and aquatic invertebrates to target substances in sediment and the diet.
- Evaluation of extensive site-specific data on the status of periphyton, benthic invertebrate and fish communities available from the *Phase I Study* (Fox Consultants, Inc. 1984a) and Herricks (1982).
- Evaluation of exposures and for terrestrial wildlife.

The overall conclusions in the executive summary of the report include:

- None of the target substances are considered to be an environmental threat requiring immediate remedial action.
- Arsenic, sulfate, selenium, cadmium, copper, cyanide and pH were determined to pose an environmental concern to one or more of the environmental media examined. Of these target substances arsenic most commonly posed an environmental concern.
- Cadmium and selenium were generally found to be of only possible environmental concern.
- Cyanide was identified to be of concern in surface waters of Whitewood Creek.
- Mercury, silver, lead, manganese, iron, chromium, copper, nickel and zinc were all found to be of possible environmental concern in at least one media.

The last paragraph of the executive summary, however, provides one overall conclusion that seems to conflict with earlier conclusions and some of the findings of the report. This is the conclusion closely followed by subsequent risk evaluations.

*“All of the target substances except arsenic were generally found to be of no environmental concern to the majority of the media examined in the study area. However, all of them were found to pose a possible environmental concern to at least one of the media examined. Of the substances considered to be of environmental concern, arsenic was the most significant throughout the environmental media under consideration.”*

**1985- *Assessment of Exposure and Possible Effects on Human Health of Gold Mine Tailings in the Whitewood Creek Area of South Dakota***

This report was prepared to identify and assess the pathways of possible exposure and impact on human health of gold mine tailings in the 18-mile area of Whitewood Creek. The report was written in response to the results of the Phase II Study (Fox Consultants, Inc., 1984b) which did not distinguish between the potential effects on soil, livestock, aquatic life and human health effects. The authors interpreted the Phase II results as a broad review that concluded there were no significant threats posed by substances associated with mine wastes. This interpretation is not substantiated by the information presented in the Phase II Study results.

**1989- *Composition, Distribution and Hydrologic Effects of Contaminated Sediments Resulting from the Discharge of Gold Milling Wastes to Whitewood Creek at Lead and Deadwood, South Dakota***

The U.S. Geological Survey (USGS) (USGS, 1989; also referred to as Goddard, 1989) measured the concentrations of major trace constituents in visually identified waste materials from the Belle Fourche River and Whitewood Creek Floodplains and background soils. Goddard describes the samples collected as “sediments”. The samples however were of soils within the floodplain of Whitewood Creek and the Belle Fourche River. Most of the “sediment” samples were collected from shallow trenches dug into streambank deposits and are hereafter referred to as overbank deposit soils. Goddard’s data set for contaminated soils consists largely of samples from the Belle Fourche River outside of the 18 mile Whitewood Creek Study area. It was not possible to identify in the electronic data files received from USGS to identify the data points taken from the Whitewood Creek Floodplain.

USGS (1989) evaluated the constituent concentrations in contaminated soils (visual evidence of tailings deposits) compared to uncontaminated soils along with other supporting information and he concluded that:

- Arsenic, cadmium, copper and silver are trace constituents known to be associated with the ore and have arithmetic mean concentrations ranging from 4 to 200 times higher in contaminated versus uncontaminated soils.
- Iron and manganese are also trace constituents of the ore but there are many other sources of these metals in the environment and the concentrations measured are only several times larger than those in uncontaminated soils.
- Chromium, lead, nickel, selenium, and zinc are not concentrated in the ore and there are no substantial differences between the concentrations in the contaminated soils versus non-contaminated soils. Chromium, nickel and selenium are not associated with either the ore mineralogy or the ore processing. Lead and zinc materials are known to occur in the ore body but are apparently rare.

- Cyanide and mercury are trace constituents contributed largely by ore processing and were detected in many of the contaminated soil samples but were not found above the detection limit in uncontaminated soil samples.
- Application of the Wilcoxon rank-sum and the Kruskal-Wallis statistical tests indicate that statistically significant (0.05 significance level) differences exist between the concentrations for all trace constituents between the contaminated and non-contaminated soils, except for lead and nickel (USGS, 1989).

Goddard's study identified based on his evaluation and rationale a list of six constituents of concern including arsenic, cadmium, copper, cyanide, mercury and silver. This list was used by subsequent investigators (in the EA primarily) to substantiate the list(s) of constituents evaluated for potential risks. Goddard's list is not however used to identify constituents of concern for the SERA. The logic used by Goddard to identify constituents of concern was conflicting and could not be applied equally to sediment contaminants. For example, Goddard did not identify chromium, lead, nickel, selenium or zinc as being constituents of concern yet these constituents are elevated in site soils in comparison to background concentrations. Goddard's own statistical analyses identified a significant difference in concentrations between site and background for chromium, selenium and zinc.

### ***1989- Endangerment Assessment for the Whitewood Creek Superfund Site***

The EA primarily focuses on evaluation of risks to human health but does provide an evaluation of impacts on aquatic species and terrestrial species. Ten metals were selected for evaluation including arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium and silver. These metals were selected based on the results of USGS (1985) (as cited in the EA) with the exception of nickel, which was added for evaluation in the EA. This list is shorter than the list of fourteen constituents evaluated in the *Phase II Study*.

The evaluation of impacts to terrestrial species is limited to the following:

- The authors state there is little available information on the possible impacts of site related chemicals to terrestrial animals along Whitewood Creek. They discuss a study completed by Hesse et al. (1975) on the accumulation of mercury in fish-eating birds inhabiting the Cheyenne River downstream of the Belle Fourche River and Whitewood Creek and conclude there is no current information and offer no further evaluation of potential risks for terrestrial species.
- A discussion of reports of sickness and death in cattle in the vicinity of mine tailing deposits including reported cattle kills downstream from Whitewood Creek along the Belle Fourche River in 1976, 1981 and 1986 is provided. There is no evaluation of the possibility of exposures and risks occurring within the Whitewood Creek Site area based on observed soil concentrations.
- A discussion of potential exposure levels of arsenic, copper and cadmium for terrestrial animals is provided. However, the significance of the exposures (potential risks) for terrestrial animals is not interpreted. The authors state that exposures could not be quantified as metal concentrations are not available in animal tissues making it difficult to rigorously address impacts.

The evaluation of impacts to aquatic ecosystems is based on comparison of total recoverable concentrations measured by USGS (1985) to USEPA ambient water quality criteria (acute and chronic).

The results of this screening step showed six constituents (arsenic, cadmium, copper, lead, mercury and silver) had geometric mean concentrations higher than respective chronic AWQC values. These same six constituents plus zinc had maximum detected concentrations exceeding respective acute AWQC values. Based on the results of the screening, a more quantitative assessment was performed that examined the relationships between location, aquatic species, constituent speciation and phase, water quality characteristics, duration of exposure and toxicological criteria. The results of these analyses indicated a potential for unacceptable adverse effects appear possible. Elements of most concern were copper and cyanide. Elements of moderate concern were cadmium, iron, mercury and silver. Lead and nickel were of minor concern and arsenic, chromium, selenium and zinc were of no concern.

#### **1988- *An Evaluation of Aquatic Life Impacts Presented in the Draft Battelle Whitewood Creek Endangerment Assessment***

This report reviewed the conclusions of the then draft EA (USEPA, 1989a) pertaining to the evaluation of impacts to aquatic life. The study evaluated the surface water quality sampling results before and after the installation and operation of the wastewater treatment system by HMC in late August of 1984. The report concludes that the metals identified as being of concern (most, moderate, or minor) in the EA were associated with the discharge of untreated effluent discharge and not the release of metals for tailings. While the study results demonstrate a decrease in metals concentrations in the stream after the installation of the treatment plant compared to before, there are still in stream metals concentrations that exceed respective AWQC.

#### **1990- *Record of Decision (ROD)***

The study completed by Fox Consultants, Inc. (1984a,b) and the EA completed in 1989 by EPA are the basis of the remedial decision making in the FS and the ROD (USEPA, 1990a). Arsenic is the only constituent of interest addressed in the ROD based on an interpretation of the results presented in the *Phase II Study* (primarily the last paragraph of the executive summary) (Fox Consultants, Inc., 1984b).

The ROD interpreted the *Phase II Study* and *EA* results and concluded that chromium, silver, nickel, iron, mercury, lead, zinc and cyanide were near background levels and were not of environmental concern (USEPA, 1990a). Cadmium, copper and manganese were dismissed as they were detected at concentrations below those of concern for human health. Sulfate and selenium were determined to be naturally occurring. Therefore, arsenic remained as the only constituent of concern.

The ROD describes the following environmental risks associated with arsenic:

“Remedial investigation activities completed prior to installation of HMC’s wastewater treatment plant indicate that populations of recreational or commercial significance were not at risk at or near the site. The Fox study, for example, reported 16 non-game species of fish and a variety of invertebrates in the waters prior to installation of Homestake Mining’s wastewater treatment plant.” The FS assumed (without substantiation) that the improved quality of the treated water observed resulted in an improved habitat in Whitewood Creek.

“Whitewood Creek below the Crook City Bridge is designated by the State of South Dakota as a warm water, semi-permanent fishery, and meets the State criteria for this use (few toxic contaminants are included in the criteria). The levels of dissolved arsenic at the downstream end of the site have approached the criteria established by the EPA for chronic toxicity to aquatic life

of 0.190 mg/L. The EPA water quality criteria and the criteria for the State of South Dakota are based on protectiveness to the aquatic habitat. Since these levels are not exceeded, it is assumed that the aquatic habitat is currently not threatened or endangered. However, because the current release of arsenic into the surface water is uncontrolled, there is a possibility of exceedances of these criteria in the future. Monitoring of surface water quality is therefore part of EPA's selected remedy for this site."

"Although some of the tailings deposits remain barren, an abundant plant community with limited diversity has gradually colonized the tailings over the years. The succession appears to begin when grasses take root in leaf litter trapped in depression in the surface of the tailings. Some trees in the tailings deposits have been dated at over 100 years old."

"Some native plants growing on the tailings deposit areas contain concentrations of arsenic above that of vegetation from the reference area. It appears however, that arsenic is only one of the limiting factors for establishing a normal plant community on the tailings deposits. Other factors such as the presence of other minerals, clay content, soil pH and permeability may act independently in restricting growth, or may control the phytotoxicity of arsenic in this environment."

"An informal survey of site residents indicates that deer, turkey, grouse and other wildlife are common in the area. A field survey for threatened or endangered species is presently underway".

The interpretation and statement of environmental risks included in the ROD is not completely accurate. For example:

- There are studies of Whitewood Creek that suggest the environmental populations of commercially significant species were at risk prior to the installation of the treatment system. For example, fisheries data obtained in the early 1980s indicate that no fish were present in the lower third of Whitewood Creek. The lack of fish in the lower reach was attributed to discharges from HMC and municipal wastes. A 1982 study describes a macroinvertebrate community that is significantly impacted by the discharges entering Whitewood Creek and reports that the major impact occurs below the confluence of Gold Run (Herricks, 1982). Further information on the status of periphyton, benthic macroinvertebrate and fish communities in 1984 is available from the Phase I Study (Fox Consultants, Inc. 1984a) but is not interpreted.
- The *Phase I Study* (Fox Consultants, Inc., 1984a) states that concentrations of arsenic, cadmium, iron and mercury are elevated in comparison to background native soils. Selenium was detected at several tailings sites but was not detected in natural soils. This information contradicts the identification of arsenic as the primary constituent of concern.
- The *EA* (USEPA, 1989a) on the basis of a detailed, quantitative assessment of potential impacts to aquatic life associated with constituents of concern in Whitewood Creek surface water, concluded that copper and cyanide were of most concern; cadmium, iron, mercury, and silver were of moderate concern and arsenic was of no concern. This contradicts the identification of arsenic as the primary constituent of concern.
- The potential phytotoxicity of metals in soils to plants was evaluated in the Phase II Study (Fox Consultants, Inc., 1984a) where arsenic, cadmium and copper were classified as either of

environmental concern or possible environmental concern. Phytotoxicity was not evaluated in the EA (USEPA, 1989a) but does provide the following statement: “Based on their analyses, Fox Consultants concluded that levels of arsenic found in “native” vegetation were sufficiently high that the productivity of some plants might be limited and that toxic responses in some arsenic-sensitive animals may occur.”

## **APPENDIX B**

### **WILDLIFE REPRESENTATIVE SPECIES PROFILES AND EXPOSURE FACTORS**

## American Dipper (*Cinclus mexicanus*)

**Order *Passeriformes*, Family *Cinclidae*.** Although there are five species of dippers worldwide, the American dipper (*Cinclus mexicanus*) is the only species which occurs in North America. The American dipper - also known as the water ouzel - is named after its constant dipping and bobbing motions. The dipper has a slender bill, pale legs, and a stocky slate-gray body with a short tail. Both males and females look similar, however juveniles are typically paler in color than adults. Dippers are usually found along mountain streams and feed primarily on aquatic invertebrates.



**Body Size and Characteristics.** Dippers range in length from 5½ to 7½ inches and typically weigh between 55 and 61 grams. Dippers are specially adapted to dive and walk underwater into the fast, oncoming water. They have nasal flaps to cover their nostrils when diving, large preening oil glands to aid with waterproofing their feathers, muscular modifications to help them swim with their wings, an ability to decrease the blood supply to non-vital tissues and organs to allow more oxygen circulate in their bloodstream, and a heavy coat of down between their dense feathers to withstand freezing mountain stream temperatures.

**Habitat.** Dippers prefer swift-flowing mountain streams, and are found less frequently along mountain ponds and lakes. American dippers are sensitive to stream pollution which affects production of aquatic invertebrate larvae and impacts water clarity which decreases their ability to see prey. Also important is the prevalence of protected nesting sites overlooking the water such as rock or cliff ledges and under bridge overpasses.

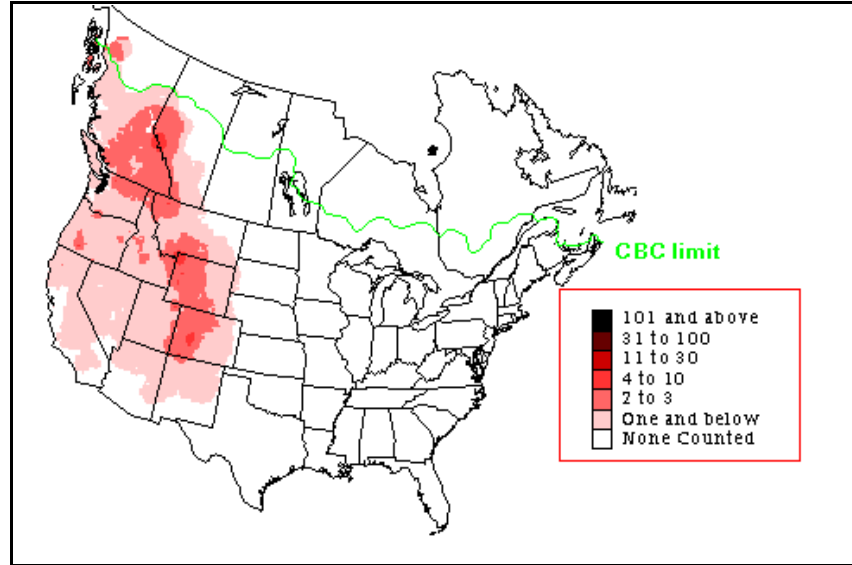
**Food Habits.** The American dipper diets consists almost exclusively of aquatic invertebrates such as *Plecoptera* (stoneflies), *Ephemeroptera* (mayflies), and *Trichoptera* (caddisflies). They will also eat clams, snails, some trout fry.

**Migration.** The dipper is a permanent resident in western and northeastern Alaska, north-central Yukon, northern British Columbia, southwestern Alberta, southwestern South Dakota, southern California and highlands of Mexico to western Panama. Because they are non-migratory, dippers often will stay within one watershed throughout their life. Seasonal movements are typically from upstream spring and summer nesting areas to winter feeding areas lower portions of streams which are free from ice.

**Breeding Activities and Social Organization.** Dipper are typically solitary, except during the nesting season where pairs will defend linear territories along streams. Usually nests are located on a raised site overlooking the water; such as on rocks in streams, cliff ledges, under waterfalls, and on overpass bridges. Nests are composed of moss, grass and roots, with an inner lining of dry, coarse grass. Typically, dippers generally lay their eggs from April through June, however at higher elevations egg laying may occur later. The average clutch size is four eggs, which are incubated by the female for 15 to 18 days. The altricial young are cared for by both parents for approximately 24 days before fledging.

**Home Range and Resources.** The American dipper is highly territorial and may defend more than a half mile of stream in summer and as much as 1,000 feet of stream in winter. Like other songbirds, the dipper declares its territory by singing.

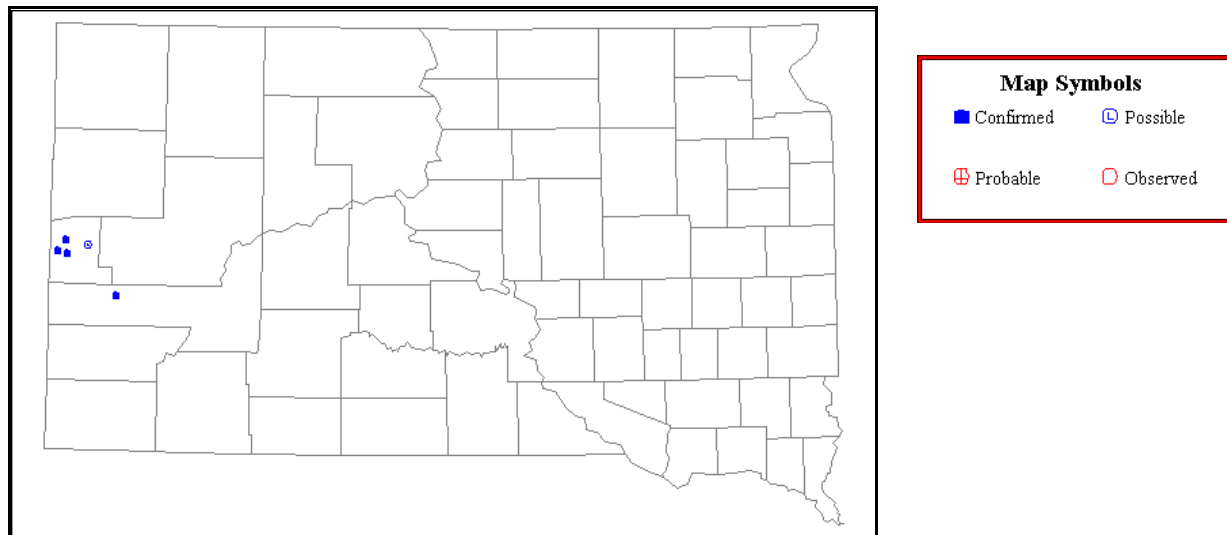
### Distribution of the American Dipper in North America



CBC - Christmas Breeding Survey. This survey is performed in one calendar day any time from mid-December to early January by volunteers. Birds are counted in an area with a 15 mile radius.

Source: Gough et al., 1998

### Distribution of the American Dipper in South Dakota



Source: Peterson, 1995

**South Dakota Status.** Rare, found only in the Black Hills; State Threatened (ST)

---

References:

Alaska Department of Fish & Game (ADF&G). 2001. Juneau, Alaska, USA. ADF&G Wildlife Notebook Series.  
Available: <http://www.state.ak.us/local/akpages/FISH.GAME/notebook/notehome.htm>

Bird, David A. 1999. "Bird's Eye View: Unique Dipper can fly underwater." Unabridged version of The Montreal Gazette column on August 7, 1999.  
Available: <http://www.trailnotes.com/wildlifers/davidbird/1999/col080799.htm>

Gough, G.A., Sauer, J.R., Iliff, M. Patuxent Bird Identification Infocenter. 1998. Version 97.1. Patuxent Wildlife Research Center, Laurel, MD.  
Available: <http://www.mbr-pwrc.usgs.gov/Infocenter/infocenter.html>

NatureServe: An online encyclopedia of life [web application]. 2001. Version 1.3 . Arlington, Virginia, USA: Association for Biodiversity Information.  
Available: <http://www.natureserve.org/>

Over, William H. and Thomas, Craig S. 1946. Birds of South Dakota, Revised Edition. Natural History Studies, Number One. University of South Dakota Museum, Vermillion, South Dakota. January, 1946.

Peterson, Richard A. 1995. The South Dakota breeding bird atlas. South Dakota Ornithologists' Union. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page. (Version 06JUL2000).  
Available: <http://www.npwrc.usgs.gov/resource/distr/birds/sdatlas/sdatlas.htm>

### **Mink (*Mustela vison*)**

(text from USEPA, 1993)

**Order *Carnivora*, Family *Mustelidae*.** The mink is the most abundant and widespread carnivorous mammal in North America. Although varied in size, most members of this family have long, slender bodies and short legs. The more terrestrial species feed on small mammals and birds, while mustelids that live around lakes and streams feed on aquatic prey such as fish, frogs, and invertebrates. It is common throughout its range but often overlooked because of its solitary nature and nocturnal activity. Mink are particularly sensitive to PCBs and similar chemicals, and have been found to accumulate PCBs in the subcutaneous fat at 38 to 200 times dietary concentrations.



**Body Size and Characteristics.** The mink is a medium-sized mammal with an elongate body, a long tail, small rounded ears, relatively short legs, and webbed toes; its pelage is soft, luxurious, and generally rich brown to almost black. Body size varies greatly throughout the species' range, with males weighing markedly more than females (in some populations, almost twice as much). Males measure from 33 to 43 centimeters in length with a 18 to 23 centimeters tail; females measure from 30 to 36 centimeters in length with a 13 to 20 centimeter tail.

**Habitat.** Mink are distributed throughout North America, except in the extreme north of Canada, Mexico, and arid areas of the southwestern United States. Mink are found associated with aquatic habitats of all kinds, including waterways such as rivers, streams, lakes, and ditches, as well as swamps, marshes, and backwater areas. Mink prefer irregular shorelines to more open, exposed banks. They also tend to use brushy or wooded cover adjacent to the water, where cover for prey is abundant and where downfall and debris provide den sites.

**Food Habits.** Mink are predominantly nocturnal hunters, although they are sometimes active during the day. Shorelines and emergent vegetation are the mink's principal hunting areas. Mink are opportunistic feeders, taking whatever prey is abundant. Mammals are the mink's most important prey year-round in many parts of their range, but mink also hunt aquatic prey such as fish, amphibians, and crustaceans and other terrestrial prey such as birds, reptiles, and insects, depending on the season. Females tend to be limited to smaller prey than males, who are able to hunt larger prey such as rabbits and muskrats more successfully.

**Breeding Activities and Social Organization.** Mating occurs in late winter to early spring. Variation in the length of mating season with different subspecies reflects adaptations to different climates. Ovulation is induced by mating, and implantation is delayed. Birth generally occurs in late spring, and the mink kits are altricial. Mink are generally solitary, with females only associating with their young of year. Mink reach sexual maturity at 10 months to a year and may reproduce.

**Home Range and Resources.** Female home ranges generally do not overlap with the home ranges of other females, nor do the home ranges of males overlap with each other. The home range of a male may overlap the home range of several females, however, particularly during the breeding season. The home range of mink encompasses both their foraging areas around waterways and their dens. When denning, mink use bank burrows of other animals, particularly muskrats, as well as cavities in tree roots, rock or brush piles, logjams, and beaver lodges. Home range size depends mostly of food abundance, but also on the age and sex of the mink, season, and social stability. Adult male home range sizes may range over 1,000 hectares during the mating season.

**South Dakota Status.** Not identified as threatened or endangered in the state of South Dakota. Mink are fairly abundant in South Dakota along water courses throughout the Black Hills. Mink in South Dakota are darker in color than those in the southern part of North America where mink have lighter red fur.

---

References:

Alaska Department of Fish & Game (ADF&G). 2001. Juneau, Alaska, USA. ADF&G Wildlife Notebook Series. Available: <http://www.state.ak.us/local/akpages/FISH.GAME/notebook/notehome.htm>

Barbour, R.W. and W.H. Davis. 1974. Mammals of Kentucky. Lexington, KY: University of Kentucky Press. 322p.

Beyer, W.N., E.E. Conner, and S. Gerould. 1994. "Estimates of Soil Ingestion by Wildlife." J. Wildl. Manage., 58(2):375-382.

Hoffmeister, D.F. 1989. Mammals of Illinois. Urbana, IL: University of Illinois Press. 348p.

Jones, Jr., J.K.J. and E.C. Birney. 1988. Handbook of Mammals of the North Central States. Minneapolis, MN: University of Minnesota Press. 346p.

Merritt, J.F. 1987. Guide to the Mammals of Pennsylvania. Pittsburgh, PA: University of Pittsburgh Press. 408p.

Schwartz, C.W. and E.R. Schwartz. 1981. The Wild Mammals of Missouri, Revised Edition. Columbia, MO: University of Missouri Press and Missouri Dept. Conserv. 356p.

Turner, R.W. 1974. Mammals of the Black Hills of South Dakota and Wyoming. University of Kansas, Museum of Natural History Miscellaneous Publication No. 60. University of Kansas Printing Office, Lawrence, Kansas. April 3, 1974.

United States Environmental Protection Agency (USEPA). 1993. Wildlife Exposure Factors Handbook, Volume I of II. Office of Research and Development, Washington, D.C. EPA/600/R-93/187a.

**Meadow Vole (*Microtus pennsylvanicus*)**  
(text from USEPA, 1993)

**Order Rodentia, Family Muridae, Subfamily Arvicolinae.** Meadow voles are small herbivorous rodents that reside in all areas of Canada and the United States where there is good grass cover. Their presence is characterized by narrow runways through matted grasses. It is the most widely distributed small grazing herbivore in North America and is found over most of the northern half of the United States.



**Body Size and Characteristics.** The meadow vole measures 8.9 to 13 centimeters in length (head and body) and has a 3.6 to 6.6 centimeter tail. They weigh between 20 and 40 grams depending on age, sex, and location. Mature males are approximately 20% heavier than females. Meadow voles lose weight during the winter, reaching a low around February, then regain weight during spring and summer, reaching a high around August in many populations. Although primarily terrestrial, the meadow vole is a strong swimmer. In winter, they do not undergo hibernation or torpor; instead, they are active all year round.

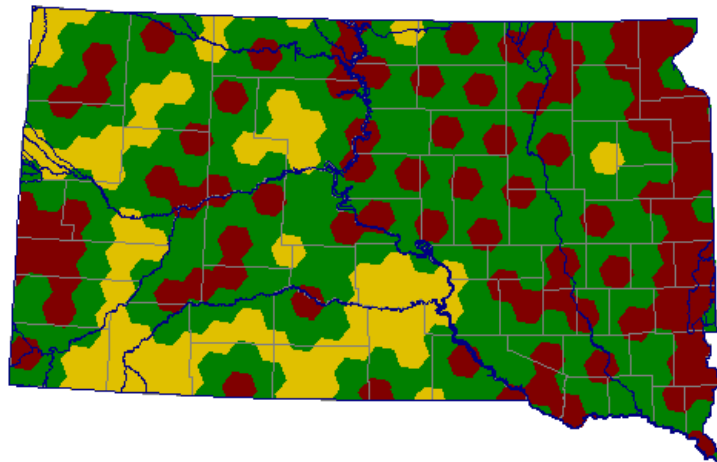
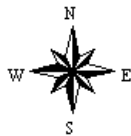
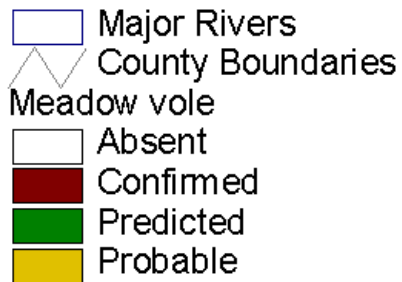
**Habitat.** The meadow vole inhabits grassy fields, marshes, and bogs. It prefers fields with more grass, more cover, and fewer woody plants, but will also inhabit moist to wet habitats. Dense vegetative cover appears to be one of the major prerequisites for habitation.

**Food Habits.** Meadow voles consume green succulent vegetation, sedges, seeds, roots, bark, fungi, insects, and animal matter. In seasonal habitats, meadow voles favor green vegetation when it is available and consume other foods more when green vegetation is less available. Activity occurs during both day and night throughout the year, although it is greatest at dawn and dusk. The meadow voles' large cecum allows it to have a high digestive efficiency of 86 to 90 percent.

**Breeding Activities and Social Organization.** Meadow voles are polygynous. Males form a hierarchy in which the most dominant voles breed. Voles produce litters throughout the breeding season, the number of litters per season increases with decreasing latitude. Elaborate spherical nests are commonly built aboveground in the center of a tussock of grass, although below ground nests are also built in drier areas. Nests are built with the use of dead grass in patches of dense, live grass. Meadow voles reach sexual maturity usually within several weeks after birth, with females maturing before males, but still continue to grow for several months. The meadow vole is one of the most prolific mammals, producing litter after litter in rapid succession. Breeding occurs during the warmer months of the year. The gestation period is about 21 days with litter sizes averaging from 4 to 7 young. The helpless young mature rapidly and may breed by 25 days of age.

**Home Range and Resources.** The area encompassed by a meadow vole's home range depends on season, habitat, population density, and the age and sex of the animal. Summer ranges tend to be larger than winter ranges, and ranges in marshes tend to be larger than ranges in meadows. Home range size also declines with increasing population density. Populations tend to fluctuate drastically every two to five years, with peak population density levels exceeding 100 voles per acre. Female meadow voles defend territories against other females, whereas male home ranges are larger and often overlap with home ranges of both sexes. Meadow voles build runways in grasses and vegetation at the ground's surface and use the runways for foraging about 45% of the time, depending on weather and other factors.

## Distribution of Meadow Vole in South Dakota



Source: SDSU, 2001.

### References:

- Barbour, R.W. and W.H. Davis. 1974. Mammals of Kentucky. Lexington, KY: University of Kentucky Press. 322p.
- Beyer, W.N., E.E. Conner, and S. Gerould. 1994. "Estimates of Soil Ingestion by Wildlife." *J. Wildl. Manage.*, 58(2):375-382.
- Hoffmeister, D.F. 1989. Mammals of Illinois. Urbana, IL: University of Illinois Press. 348p.
- Jones, Jr., J.K.J. and E.C. Birney. 1988. Handbook of Mammals of the North Central States. Minneapolis, MN: University of Minnesota Press. 346p.
- Merritt, J.F. 1987. Guide to the Mammals of Pennsylvania. Pittsburgh, PA: University of Pittsburgh Press. 408p.
- Schwartz, C.W. and E.R. Schwartz. 1981. The Wild Mammals of Missouri, Revised Edition. Columbia, MO: University of Missouri Press and Missouri Dept. Conserv. 356p.
- South Dakota State University (SDSU). 2001. South Dakota Gap Analysis Project (SD-GAP). Conducted by the Department of Wildlife and Fisheries Sciences and South Dakota Cooperative Fish and Wildlife Research Unit as a part of the National Gap Analysis Program headed by the USGS, Biological Resources Division.  
Available at: <http://wfs.sdstate.edu/sdgap/mammal/redfox.html>.
- United States Environmental Protection Agency (USEPA). 1993. Wildlife Exposure Factors Handbook, Volume I of II. Office of Research and Development, Washington, D.C. EPA/600/R-93/187a.

***Masked shrew (Sorex cinereus)***

**Order Sorex, Family cinereus.**

**Body Size and Characteristics.** Adult masked shrews weigh between 2 and 5 grams and range in length from 69 to 111 mm. Masked shrews range in color from grayish brown to brownish black to black with tan or dusky feet. There may be a darker coloration over the eyes for which the animals were named; however, this dark coloration is not always apparent. Shrews are small in size, have a long pointed snout, smaller than ordinary eyes, and short ears. Furthermore, masked shrews are distinguished from other shrews by having a the longest tail (Schwartz and Schwartz 1981).



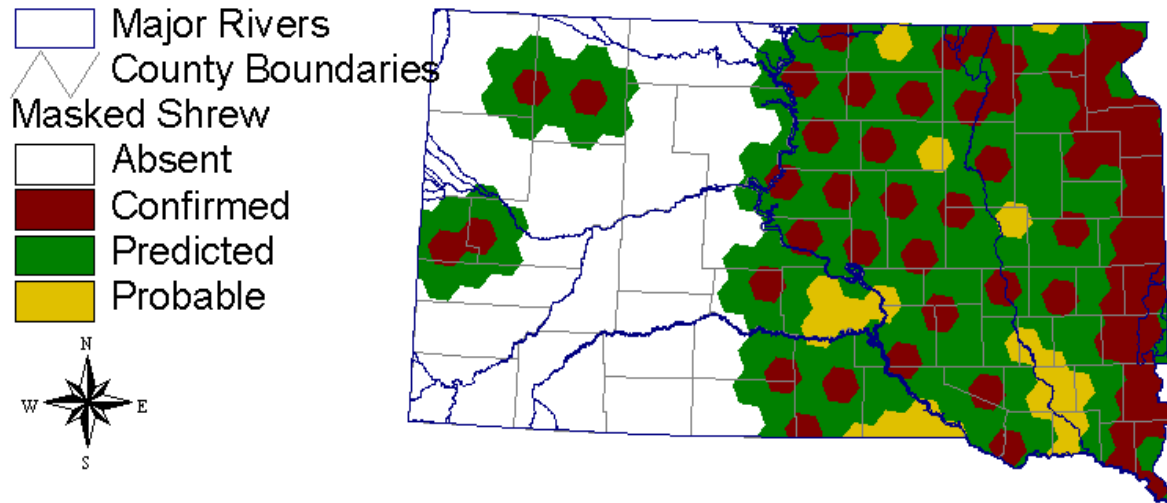
**Habitat.** Masked shrews are nocturnal, non-hibernating, and remain active throughout the entire year. Shrews live in burrows that are approximately 3/4 inch in diameter that may descend about 9 inches. Their tunnel system may have several chambers including those for food storage, resting, and nesting. It has also been observed that the masked shrew's activity level increases following rainfall. Therefore, they prefer moist areas, such as a low damp areas in stream valleys or flood plains. The masked shrew lives in the same general area as the least shrew (*Cryptotis parva*) (Schwartz and Schwartz 1981).

**Food Habits.** Shrews are voracious insect-feeding mammals, eating 3 times their own weight every 24 hours. Masked shrews mainly eat butterflies, moths, and beetle larvae, slugs, snails, and spiders. These shrews rarely eat vegetables (Schwartz and Schwartz 1981).

**Breeding Activities and Social Organization.** The average life span of a masked shrew is only 12 - 18 months and therefore may have several litters per season with 4 to 10 individuals per litter. A female may be nursing one litter and pregnant with a second. Mortality is greatest during the first 2 months and excessive rainfall and wetness may be the major cause of death in the nest (Schwartz and Schwartz 1981).

**Home Range and Resources.** The masked shrew has a wide geographic range found from Alaska and Canada into the northern half of the U.S. While it is relatively scarce over the entire range, it may be very abundant in certain areas.

## Distribution of Masked Shrew in South Dakota



*Source: SDSU, 2001*

---

### References:

Schwartz, C.W. and E.R. Schwartz. 1981. The Wild Mammals of Missouri, Revised Edition. Columbia, MO: University of Missouri Press and Missouri Dept. Conserv. 356p.

South Dakota State University (SDSU). 2001. South Dakota Gap Analysis Project (SD-GAP). Conducted by the Department of Wildlife and Fisheries Sciences and South Dakota Cooperative Fish and Wildlife Research Unit as a part of the National GAP Analysis Program headed by the USGS, Biological Resources Division. Available at: <http://wfs.sdstate.edu/sdgap/mammal/maskedshrew.html>.

### **Great Horned Owl (*Bubo virginianus*)**

**Order Strigiformes, Family Strigidae.** The great horned owl - sometimes called the “cat owl” or “hoot owl” - is one of the most widespread and commonly recognized owls. It is the largest owl in North America and easily identified by its prominent ear tufts, yellow eyes, and distinct hooting call.

**Body Size and Characteristics.** The great horned owl has a light brown body, spotted with darker brown; its white throat feathers contrast with rest of the dark cross-banded underparts. It is a very large owl, approximately 20 inches long, with an impressive wingspan of 55 inches. It has prominent widely spaced ear tufts, yellow eyes with reddish-brown facial disks bordered by black and a dark bill. Both sexes are similar in appearance although the female is larger in size. An adult male great horned owl weighs from 1 to 1.5 kilograms and a female great horned owl weighs from 1.5 to 2.5 kilograms.



**Habitat.** This species occurs in a wide range of habitats including deep forests, open country, deserts, canyons, and city parks.

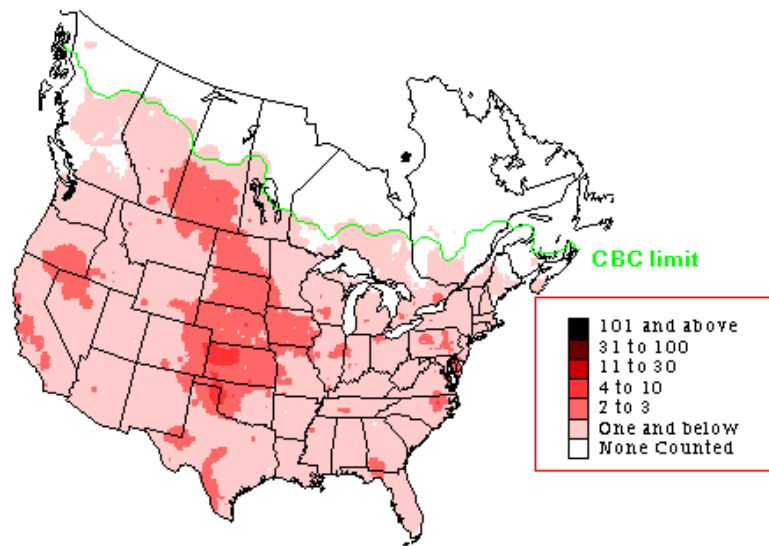
**Food Habits.** The great horned owl is mainly nocturnal, but hunts both by day and by night in woods, mountains, marshes, dunes, and in open desert. It feeds mainly on a wide range of small mammals and lesser quantities of reptiles, amphibians, fish, and birds.

**Migration.** Great horned owls are a permanent resident of most states and found throughout North America, in western and central Alaska to southern Keewatin and Labrador and in south to southern South America. The northernmost populations partially migratory, wintering south to southern Canada and northern United States.

**Breeding Activities and Social Organization.** The great horned owl nests can be found in natural tree cavities, on a rock ledges, and even in rock or earth caves. They will often use the old nest of a large bird such as a red-tailed hawk, eagle, heron, or crow. However, they will typically does not use same tree nest in successive years. The nest is an unlined cavity or lined with any material already present. Great horned owls are one of the first species to nest, and breeding begins in late November or January in the south to early April in the north. The clutch size is usually 1-4 eggswith an incubation period of 26-30 days. The young first fly at 63-70 days after hatching and rely on the adults for food for a long period of time afterwards.

**Home Range and Resources.** Home range sizes for the great horned owl vary seasonally and geographically. Although density varies in different areas, it is usually about 1 pair per 5 to 20 kilometers<sup>2</sup>. Bird banding recoveries of great horned owls indicate that most individuals remain within 80 kilometers of the original banding site.

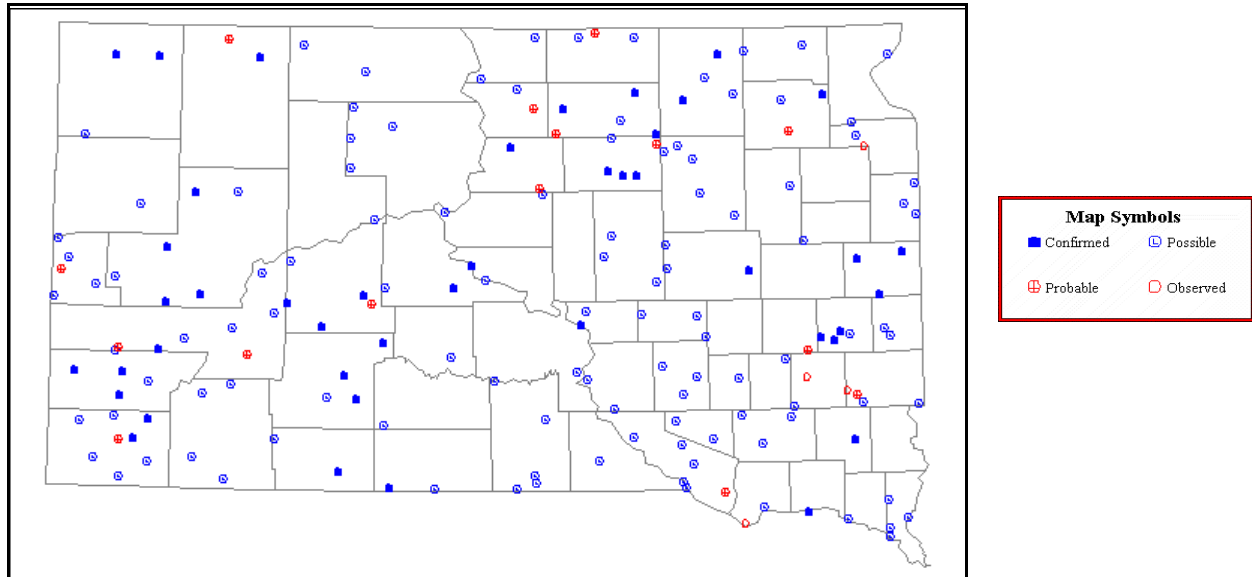
### Distribution of the Great Horned Owl in North America



CBC - Christmas Breeding Survey. This survey is performed in one calendar day any time from mid-December to early January by volunteers. Birds are counted in an area with a 15 mile radius.

Source: Gough *et al.*, 1998

### Distribution of the Great Horned Owl in South Dakota



Source: Peterson, 1995

**South Dakota.** Not identified as threatened or endangered by the state of South Dakota; common and widespread throughout the state. This species starts to nest early in the year in South Dakota, often laying eggs in late January and February with young fledging from the nest by May.

---

References:

Baichich, P. J. and C.J.O. Harrison. 1997. A Guide to the Nests, Eggs, and Nestlings of North American Birds. San Diego, CA: Academic Press. p. 186-187.

Dunning, J.B. 1993. CRC Handbook of Avian Body Masses. CRC Press, Boca Raton, Florida, 371 pp.

Earhart, C.M. and N.K. Johnson. 1970. Size Dimorphism and Food Habits of North American Owls. The Condor, 72:251-264.

Gough, G.A., Sauer, J.R., Iliff, M. Patuxent Bird Identification Infocenter. 1998. Version 97.1. Patuxent Wildlife Research Center, Laurel, MD.

Available: <http://www.mbr-pwrc.usgs.gov/Infocenter/infocenter.html>

NatureServe: An online encyclopedia of life [web application]. 2001. Version 1.3 . Arlington, Virginia, USA: Association for Biodiversity Information.

Available: <http://www.natureserve.org/>

Nichols and Warrier. 1972. "Barred owl habitat use as determined by radiotelemetry". J. Wildl Mgt., 36:23-224.

Over, William H. and Thomas, Craig S. 1946. Birds of South Dakota, Revised Edition. Natural History Studies, Number One. University of South Dakota Museum, Vermillion, South Dakota. January, 1946.

Peterson, Richard A. 1995. The South Dakota breeding bird atlas. South Dakota Ornithologists' Union. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page. (Version 06JUL2000).

Available: <http://www.npwrc.usgs.gov/resource/distr/birds/sdatlas/sdatlas.htm>

Terres, J.K. 1980. The Audubon Society Encyclopedia of North American Birds. Alfred A. Knopf, New York, NY.

**Deer Mouse (*Peromyscus maniculatus*)**

(Text from USEPA, 1993)

**Order Rodentia, Family Muridae.** The deer mouse is primarily granivorous and has the widest geographic distribution of any *Peromyscus* species. It is resident and common in nearly every dry-land habitat within its range, including alpine tundra, coniferous and deciduous forest, grasslands, and deserts. There are many recognized subspecies or races of the deer mouse associated with different locations or habitats.



**Body Size and Characteristics.** Deer mice range from 7.1 to 10.2 centimeters in length with a long tail (5.1 to 13 centimeters), and adults weight from 15 to 35 grams. Body size varies somewhat among populations and subspecies. Body weight also varies seasonally, being lower in autumn and winter and a few grams higher in spring and summer. It is gray to red-brown in color with white underneath and a distinctly bicolored and short-haired tail. The deer mouse has a metabolic rate about 1.3 times higher than other species in the genus. Deer mice can enter torpor to reduce metabolic demands in the winter and in response to brief food shortages. It may burrow in soils to assist with thermoregulation.

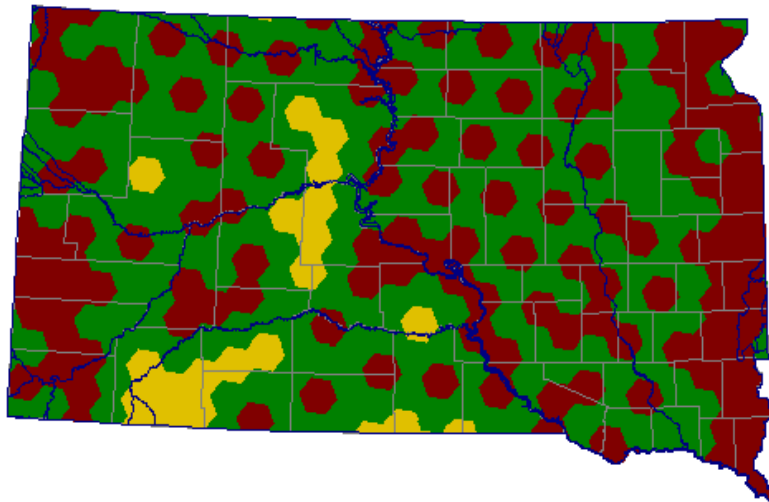
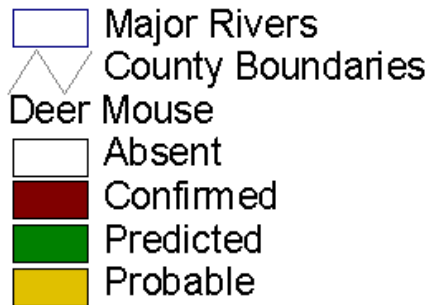
**Habitat.** Deer mice inhabit nearly all types of dry-land habitat within their range; short-grass prairies, grass-sage communities, coastal sage scrub, sand dunes, wet prairies, upland mixed and cedar forests, deciduous forests, ponderosa pine forests, other coniferous forests, mixed deciduous-evergreen forests, juniper/pinon forests, etc.

**Food Habits.** Deer mice are omnivorous and highly opportunistic, which leads to substantial regional and seasonal variation in their diet. They eat principally seeds, arthropods, some green vegetation, roots, fruits, and fungi as available. The non-seed plant materials provide a significant proportion of the deer mouse's daily water requirements. Deer mice may cache food during the fall and winter in the more northern parts of their range. They are nocturnal and emerge shortly after dark to forage for several hours.

**Breeding Activities and Social Organization.** The duration of the reproductive season varies with latitude and longitude. Nests are spherical and relatively large for the animal's size, with a single side entrance that is closed from the inside. These nests are usually located at or below the ground surface, such as in cavities at a tree base or shrub roots, under logs or rocks, or in an existing animal burrow. Nests are sometimes placed aboveground, in trees, fenceposts, or existing bird nests. Breeding occurs mostly in the spring and fall, but has been reported to occur throughout the year. Gestation lasts from 21 to 27 days, and may extend to 35 days in lactating females. Newborn deer mice are highly altricial and litter sizes range between one to nine pups (averaging three to six). Female deer mice reach breeding age by 46 to 51 days. Studies indicate that daily food consumption increases over 15% during early pregnancy and more than doubles during lactation.

**Home Range and Resources.** Deer mice tend to occupy more than one nest site. At low densities, home ranges are maintained by mutual avoidance, but at higher densities, females may defend a core area or territory. The home range of female deer mice encompasses both their foraging areas and their nests. Male home ranges are larger and overlap the home ranges of many females. Deer mice are abundant enough to form a ready supply of food for carnivorous predators.

# Distribution of Deer Mouse in South Dakota



Source: SDSU, 2001.

---

## References:

- Barbour, R.W. and W.H. Davis. 1974. Mammals of Kentucky. Lexington, KY: University of Kentucky Press. 322p.
- Hoffmeister, D.F. 1989. Mammals of Illinois. Urbana, IL: University of Illinois Press. 348p.
- Jones, Jr., J.K.J. and E.C. Birney. 1988. Handbook of Mammals of the North Central States. Minneapolis, MN: University of Minnesota Press. 346p.
- Merritt, J.F. 1987. Guide to the Mammals of Pennsylvania. Pittsburgh, PA: University of Pittsburgh Press. 408p.
- Schwartz, C.W. and E.R. Schwartz. 1981. The Wild Mammals of Missouri, Revised Edition. Columbia, MO: University of Missouri Press and Missouri Dept. Conserv. 356p.
- South Dakota State University (SDSU). 2001. South Dakota Gap Analysis Project (SD-GAP). Conducted by the Department of Wildlife and Fisheries Sciences and South Dakota Cooperative Fish and Wildlife Research Unit as a part of the National Gap Analysis Program headed by the USGS, Biological Resources Division.  
Available at: <http://wfs.sdstate.edu/sdgap/mammal/redfox.html>.
- United States Environmental Protection Agency (USEPA). 1993. Wildlife Exposure Factors Handbook, Volume I of II. Office of Research and Development, Washington, D.C. EPA/600/R-93/187a.

### Cliff Swallow (*Hirundo pyrrhonota*)

**Order *Passeriformes*, Family *Hirundinidae*.** The cliff swallow - also called eaves swallows - is one of the 74 species of swallows. It is one of the most common swallows over the central and western portions of its range, but is declining in the northeast. Cliff swallows are the famous swallows which "return to Capistrano" each year on March 19<sup>th</sup> at the San Juan Capistrano Mission in southern California.



**Body Size and Characteristics.** The cliff swallow is a small bird ranging in length from 5 to 6 inches. The cliff swallow is stocky with a square tail and pale orange rump and forehead. It is dull steel-blue on top with buff-white underparts, a dark chestnut throat, white forehead, and tiny bill. Juveniles have similar coloring to the adults except for a duller finish. Cliff swallows are most often seen flying and create mud nests under bridges and in barns and caves.

**Habitat.** Cliff swallows inhabit open country, semi-wooded habitat, cliffs, canyons, and farms; and can be found near meadows, marshes, water, buildings or cliffs. During migration they inhabit lake shores and marshes. Builds bottle shaped mud nest in colonies on overhanging areas of cliffs, eaves of buildings, under bridges, etc. The use of natural sites for nesting areas is greatest in the western United States.

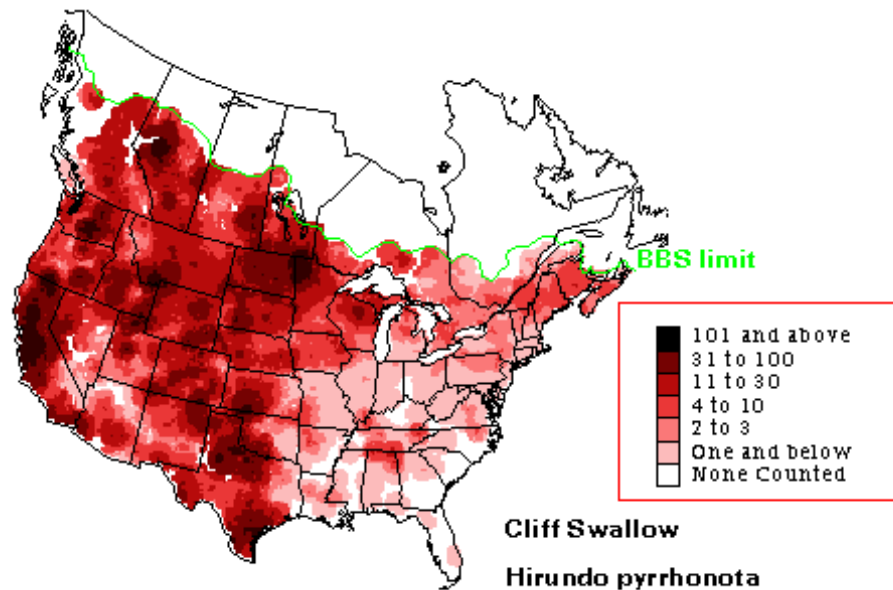
**Food Habits.** The cliff swallow is almost exclusively insectivorous; feeding on beetles, flying ants, wasps, grasshoppers, mosquitoes, and other small swarming insects.

**Migration.** The cliff swallow is widely distributed from Alaska, Ontario, and Nova Scotia south to Virginia, Missouri, and Central America. The cliff swallow winters in South America arriving in the southern portions of North America by March the northern states by April.

**Breeding Activities and Social Organization.** The cliff swallow breeding season is from early May to August in the northeastern United States. Cliff swallows are colonial nesters building their nests in sheltered cliff faces, barns, bridges and under the eaves of buildings. The nest is a gourd-shaped structure of mud, lined with feathers and grass. Nests are packed together in close knit colonies which can range in size from a few to several thousand. The clutch size is usually 3-5 with both parents participating in the 12 to 14 day incubation. Hatchlings are tended by both parents and can fly at 21-23 days, however, many fledglings return to nest for the first 2-3 days after fledging. Parents will continue to feed the young before migration begins. Usually cliff swallow will produce one brood per year, although a few will have a second brood. Breeding activity within a colony is closely synchronized. Prolonged rains or dry weather may reduce breeding success or postpone nesting. Many return to same nesting area in successive years to repair and reuse old nests, but colonies tend to switch nesting sites between seasons, evidently due to a buildup of insect parasites in the nests. At times, this parasitic swallow bug (*Oeciocercus vicarius*) is abundant enough to reduce reproductive success in large colonies.

**Home Range and Resources.** Cliff swallows usually forage within 0.5 kilometer of colony, but will sometimes forage up to several kilometers away.

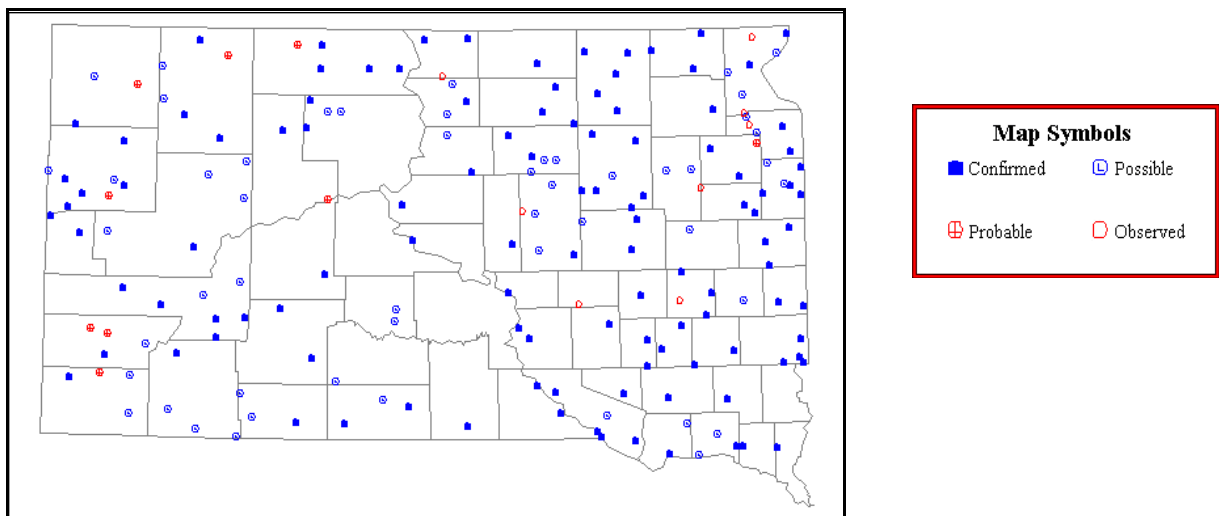
### Distribution of the Cliff Swallow in North America



BBS - Breeding Bird Survey. This survey is typically performed in June by volunteers on over 4000 bird counts. The counts are done by vehicle during the morning. Many nocturnal or less vocal species are not well surveyed by the BBS.

*Source: Gough et al., 1998*

### Distribution of the Cliff Swallow in South Dakota



*Source: Peterson, 1995*

**South Dakota Status.** Not identified as threatened or endangered by the state of South Dakota.

---

References:

Bird Barrier America, Inc. 1998. "Cliff swallow (*Petrochelidon pyrrhonota*)."  
Available: [www.birdbarrier.com/facts/factsswallow.html](http://www.birdbarrier.com/facts/factsswallow.html).

Bull, J. and J. Farrand. 1977. *The Audubon Society Field Guide to North American Birds, Eastern Region*. Alfred A. Knopf, New York, NY.

Gough, G.A., Sauer, J.R., Iliff, M. Patuxent Bird Identification Infocenter. 1998. Version 97.1. Patuxent Wildlife Research Center, Laurel, MD.  
Available: <http://www.mbr-pwrc.usgs.gov/Infocenter/infocenter.html>

NatureServe: An online encyclopedia of life [web application]. 2001. Version 1.3 . Arlington, Virginia, USA: Association for Biodiversity Information.  
Available: <http://www.natureserve.org/>

Over, William H. and Thomas, Craig S. 1946. *Birds of South Dakota, Revised Edition*. Natural History Studies, Number One. University of South Dakota Museum, Vermillion, South Dakota. January, 1946.

Peterson, Richard A. 1995. *The South Dakota breeding bird atlas*. South Dakota Ornithologists' Union. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page. (Version 06JUL2000).  
Available: <http://www.npwrc.usgs.gov/resource/distr/birds/sdatlas/sdatlas.htm>

Terres, J.K. 1980. *The Audubon Society Encyclopedia of North American Birds*. Alfred A. Knopf, New York, NY.

Zoological Society of Philadelphia. 1997. "Great horned owl."  
Available at: <http://www.phillyzoo.org/pz0052.htm>

**Belted Kingfisher (*Ceryle alcyon*, formerly *Megaceryle alcyon*)**

(text taken from USEPA, 1993)

**Order Coraciiformes, Family Alcedinidae.** The belted kingfisher is a medium-sized bird (33 cm from bill tip to tail tip) that eats primarily fish. It is one of the few species of fish-eating birds found throughout inland areas as well as coastal area. The belted kingfisher's range includes most of the North American continent; it breeds from northern Alaska and central Labrador southward to the southern border of the United States. Two subspecies sometimes are recognized: the eastern belted kingfisher *C. a. alcyon*, which occupies the range east of the Rocky Mountains and north to Quebec, and the western belted kingfisher *C. a. cauttina*, which occupies the remaining range to the west.



**Body Size and Characteristics.** The male belted kingfisher has a bluish-grey breast band, while the female is rusty in color. Its chief characteristics are a white throat and neck bands. The sexes are similar in size and appearance, although the female tends to be slightly larger. Western populations are somewhat larger than eastern ones. Nestlings reach adult body weight by about 16 days after hatching, but then may lose some weight before fledging.

**Habitat.** Belted kingfishers are typically found along rivers and streams and along lake and pond edges. They are common on seacoasts and estuaries. They prefer waters that are free of thick vegetation that obscures the view of the water and water that is not completely overshadowed by trees. Kingfishers also require relatively clear water in order to see their prey and are noticeably absent in areas when waters become turbid. They prefer stream riffles for foraging sites even when pools are more plentiful because of the concentration of fish and riffle edges. Belted kingfishers nest in burrows within steep earthen banks devoid of vegetation beside rivers, streams, ponds, and lakes; they have also been found to nest in slopes created by human excavations such as roadcuts and landfills. Sandy soil banks, which are easy to excavate and provide good drainage, are preferred. In general, kingfishers nest near suitable fishing areas when possible but will nest away from water and feed in bodies of water other than the one closest to home.

**Food Habits.** Belted kingfishers generally feed on fish that swim near the surface or in shallow water, generally catching fish in the upper 12 to 15 cm of the water column. Belted kingfishers capture fish by diving either from a perch overhanging the water or after hovering above the water. Fish are swallowed whole, head first, after being beaten on a perch. Several studies indicate that belted kingfishers usually catch the prey that are most available. Diet therefore varies considerably among different water bodies and with season. Although kingfishers feed predominantly on fish, they sometimes consume large numbers of crayfish, and in shortages of their preferred foods, have been known to consume crabs, mussels, lizards, frogs, toads, small snakes, turtles, insects, salamanders, newts, young birds, mice, and berries.

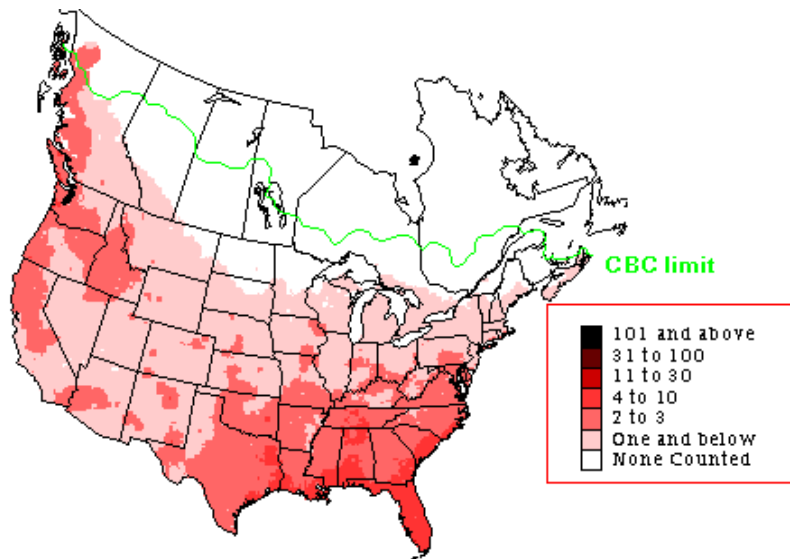
**Migration.** The kingfisher breeds over most of the area of North America and winters in most regions of the continental United States. Although most northern kingfishers migrate to southern regions during the coldest months, some may stay in areas that remain ice-free where fishing is possible.

**Breeding Activities and Social Organization.** During the breeding season, pairs establish territories for nesting and fishing; otherwise, belted kingfishers are solitary. They are not colonial nesters and will defend an unused bank if it lies within their territory. In migrating populations, the males arrive before the females to find suitable nesting territories. Kingfishers excavate their burrows in earthen banks, forming a tunnel that averages 1 to 2 meters in length, although some burrows may be as long as 3 to 4 meters. The burrow entrance is usually 30 to 90 cm from the top of the bank and at least 1½ meters from the base. Burrows closer to the top may collapse, and burrows to low and flood. Burrows may be used

for more than one season. Five to seven eggs are laid on bare substrate or on fish bones within the burrow. Only one adult, usually the female, spends the night in the nest cavity; males usually roost in nearby forested area or heavy cover. Both parents incubate eggs and feed the young. After fledging, the young remain with their parents for 10 to 15 days.

**Home Range and Resources.** During the breeding season, belted kingfishers require suitable nesting sites with adequate nearby fishing. During spring and early summer, both male and female belted kingfishers defend a territory that includes both their nest site and their foraging area. By autumn, each bird (including young of the year) defends individual feeding territory only. The breeding territories (length of waterline protected) can be more than twice as long as the fall and winter feeding territories, and stream territories tend to be longer than those on lakes. Foraging territory size is inversely related to prey abundance.

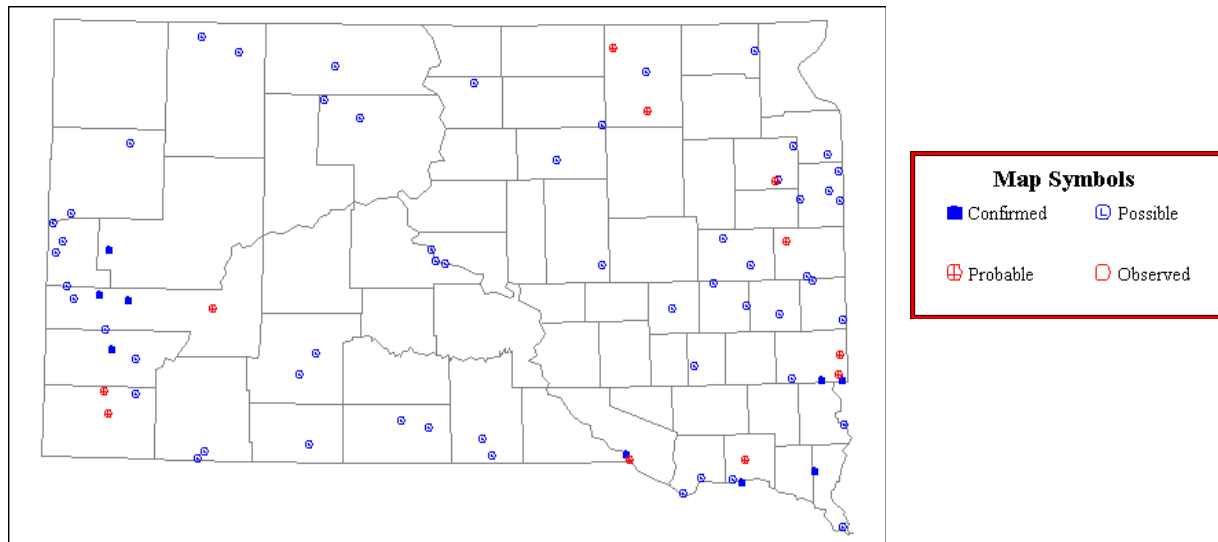
### Distribution of the Belted Kingfisher in North America



CBC - Christmas Breeding Survey. This survey is performed in one calendar day any time from mid-December to early January by volunteers. Birds are counted in an area with a 15 mile radius.

*Source: Gough et al., 1998*

### Distribution of the Belted Kingfisher in South Dakota



*Source: Peterson, 1995*

**South Dakota Status.** A summer resident of South Dakota, populations are scattered and uncommon. Not identified as threatened or endangered by the state of South Dakota.

---

References:

Gough, G.A., Sauer, J.R., Iliff, M. Patuxent Bird Identification Infocenter. 1998. Version 97.1. Patuxent Wildlife Research Center, Laurel, MD.

Available: <http://www.mbr-pwrc.usgs.gov/Infocenter/infocenter.html>

NatureServe: An online encyclopedia of life [web application]. 2001. Version 1.3 . Arlington, Virginia, USA: Association for Biodiversity Information.

Available: <http://www.natureserve.org/>

Over, William H. and Thomas, Craig S. 1946. Birds of South Dakota, Revised Edition. Natural History Studies, Number One. University of South Dakota Museum, Vermillion, South Dakota. January, 1946.

Peterson, Richard A. 1995. The South Dakota breeding bird atlas. South Dakota Ornithologists' Union. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page. (Version 06JUL2000).

Available: <http://www.npwrc.usgs.gov/resource/distr/birds/sdatlas/sdatlas.htm>

United States Environmental Protection Agency (USEPA). 1993. Wildlife Exposure Factors Handbook - Volume I of II. EPA/600/R-93/187a. Office of Research and Development. December 1993.

**American Robin (*Turdus migratorius*)**

(text taken from USEPA, 1993)

**Order *Passeriformes*, Family *Muscicapidae*, Subfamily *Turdinae*.** The American Robin occurs throughout most of the continental United States and Canada during the breeding season and winters in the southern half of the United States and Mexico and Central America. The breeding range of the robin has expanded in recent times with the increasing area covered by lawns and other open habitats.



**Body Size and Characteristics.** The sexes are similar in size and appearance. Their size varies slightly geographically; the smallest robins are found in eastern United States and along the Pacific coast, and the largest occur in the Rocky Mountains, northern Great Plains, and northern deserts. The size of robins tends to increase with latitude in eastern North America but does not in western North America. Fledglings attain adult size at approximately 6 weeks of age.

**Habitat.** Access to fresh water, protected nesting sites, and productive foraging areas are important requirements for breeding robins. Breeding habitats include moist forests, swamps, open woodlands, orchards, parks, and lawns. Robins forage on the ground in open areas, along habitat edges, or the edges of stream; they also forage above ground in shrubs and within the lower branches of trees. Nests in wooded areas are usually near some type of opening such as the forest edge or a tree-fall gap. During the non-breeding season, robins prefer moist woods or fruit-bearing trees and shrubs. In the fall, flocks of migratory robins are often found along forest edges or clearings where fruits are most plentiful.

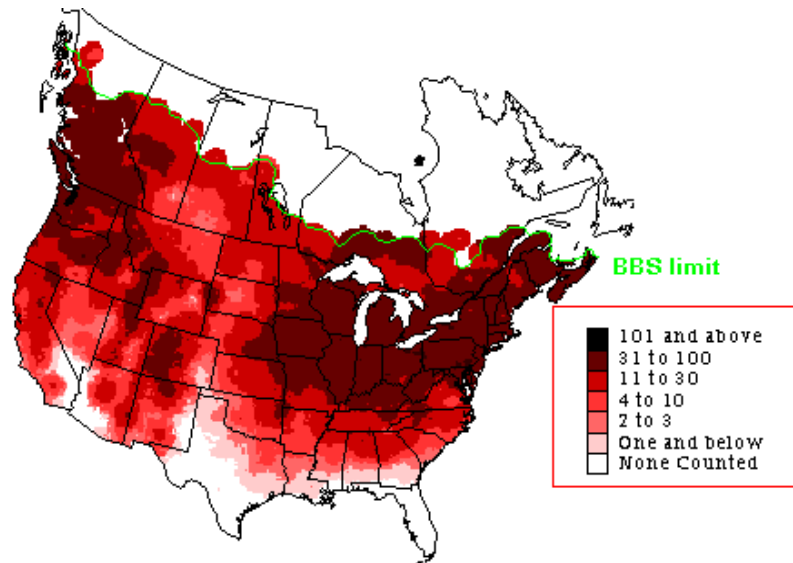
**Food Habits.** Robins forage by hopping along the ground in search of ground-dwelling invertebrates and by searching for fruit and foliage-swelling insects in shrubs and low tree branches. In the months preceding and during the breeding season, robins feed mainly (greater than 90 percent volume) on invertebrates and on some fruits; during the remainder of the year, their diet consists primarily (over 80 to 90 percent by volume) of fruits. Common invertebrates include beetles, caterpillars, moths, grasshoppers, spiders, millipeds, and earthworms. Robins exhibit a low digestive efficiency for fruits, however when eating insects they exhibit a higher digestive efficiency of approximately 70 percent.

**Migration.** Most robins nesting in the northern United States and Canada winter in the Gulf Coast States and the Carolinas. Robin flocks migrate during the day; most northern robins leave their breeding grounds from September to November and return between February and April.

**Breeding Activities and Social Organization.** The onset of the breeding season is later at higher latitudes and altitudes, but mating and egg laying generally occur in April or May. Males arrive on the breeding grounds before the females to establish territories; females pair with established males, usually for the duration of the breeding season. The female primarily builds the nest out of mud, dried grass, weedy stems, and other materials, constructing it on horizontal limbs, tree-branch crotches, within shrubs, or on any one of a number of man-made structures with horizontal surfaces. First clutches usually contain three or four eggs; later clutches tend to contain fewer eggs. The female does all of the incubating, which continues for 10 to 14 days following the laying of the second egg. Both males and females feed the nestlings. Following fledging, the brood often divides, with the male and female each feeding half of the fledglings for another 2 weeks. After reaching independence, juveniles often form foraging flocks in areas of high food availability.

**Home Range and Resources.** During the breeding season, male robins establish breeding territories, which the female helps to defend against other robins. Nonetheless, the territories of different pairs often overlap where neither pair can establish dominance. Most foraging during the breeding season is confined to the territory, but adults sometimes leave to forage in more productive areas that are shared with other individuals. In some prime nesting areas, where robin densities are high, territories are small and the birds might often forage elsewhere. Adult robins often return to the same territory in succeeding years.

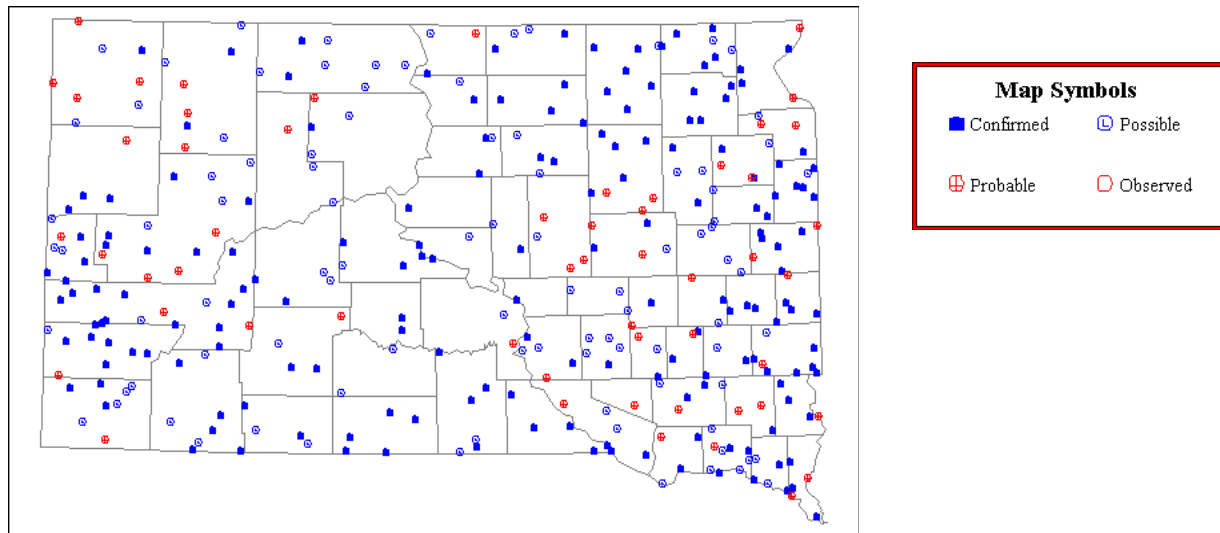
### Distribution of the American Robin in North America



BBS - Breeding Bird Survey. This survey is typically performed in June by volunteers on over 4000 bird counts. The counts are done by vehicle during the morning. Many nocturnal or less vocal species are not well surveyed by the BBS.

Source: Gough et al., 1998

### Distribution of the American Robin in South Dakota



Source: Peterson, 1995

**South Dakota Status.** Robins are abundant and widespread throughout the state of South Dakota in summer and in the southernmost areas some flocks may remain all winter. The western robin (subspecies *propinquus*) is a summer resident of the Black Hills and Harding County.

---

References:

Gough, G.A., Sauer, J.R., Iliff, M. Patuxent Bird Identification Infocenter. 1998. Version 97.1. Patuxent Wildlife Research Center, Laurel, MD.

Available: <http://www.mbr-pwrc.usgs.gov/Infocenter/infocenter.html>

NatureServe: An online encyclopedia of life [web application]. 2001. Version 1.3 . Arlington, Virginia, USA: Association for Biodiversity Information.

Available: <http://www.natureserve.org/>

Over, William H. and Thomas, Craig S. 1946. Birds of South Dakota, Revised Edition. Natural History Studies, Number One. University of South Dakota Museum, Vermillion, South Dakota. January, 1946.

Peterson, Richard A. 1995. The South Dakota breeding bird atlas. South Dakota Ornithologists' Union. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page. (Version 06JUL2000).

Available: <http://www.npwrc.usgs.gov/resource/distr/birds/sdatlas/sdatlas.htm>

United States Environmental Protection Agency (USEPA). 1993. Wildlife Exposure Factors Handbook - Volume I of II. EPA/600/R-93/187a. Office of Research and Development. December 1993.

### **American Kestrel (*Falco sparverius*)**

(text taken from USEPA, 1993)

**Order *Falconiformes*, Family *Falconidae*.** The American kestrel, or sparrow hawk, is the most common falcon in open and semi-open areas throughout North America. There are three recognized subspecies: *F. s. paulus* (year-round resident from South Carolina to Florida and southern Alabama), *F. s. peninsularis* (year-round resident of southern Baja California), and *F. s. sparverius* (widespread and migratory). Predators of the kestrel include large raptors such as the great horned owl, golden eagle, and red-tailed hawk.



**Body Size and Characteristics.** The kestrel is a small, long-tailed hawk with a short, dark, hooked beak, and long, narrow, pointed wings. Kestrels can be identified by their gray crown with a black spot at rear of the crown on both sides, white cheeks, two black mustache marks, and flight feathers that are pale with dark barring. Kestrels are approximately 8½ inches long with a wingspan of about 21 inches. Weighing slightly over one-tenth of a kilogram, the kestrel is the smallest falcon native to the United States. As for most raptors, females are 10 to 20 percent larger than the males. Kestrel body weights vary seasonally, with maximum weight (and fat deposits) being achieved in winter and minimum weights in summer.

**Habitat.** Kestrels inhabit open deserts, semi-open areas, the edges of groves, and even cities. In several areas, investigators have found that male kestrels tend to use woodland openings and edges, while females then to utilize more open areas characterized by short or sparse ground vegetation, particularly in the winter. In other areas, however, investigators have found no such differentiation. Kestrels are more likely to use habitats close to centers of human activities than are most other raptors.

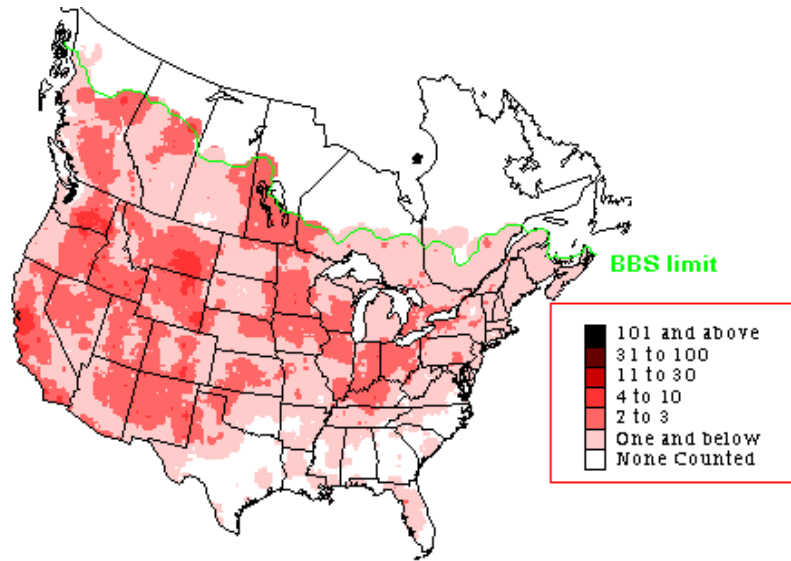
**Food Habits.** Kestrels prey on a variety of small animals including invertebrates such as worms, spiders, scorpions, beetles, other large insects, amphibians and reptiles such as frogs, lizards, and snakes, and a wide variety of small- to medium-sized birds and mammals. Large insects, such as grasshoppers, are the kestrels' primary summer prey, although in their absence kestrels will switch to small mammals and birds. In winter, small mammals and birds comprise most of the diet. Kestrels usually cache their vertebrate prey, often in clumps of grass or in tree limbs and holes, to be retrieved later. Invertebrate prey are usually eaten immediately. Kestrels forage by three different techniques: using open perches from which to spot and attack ground prey, hovering in the air to spot ground prey, and catching insects on the wing.

**Migration.** The American kestrel is a year-round resident over most of the United States, but is migratory over the northern-most portions of its range. Because of their late molt, males migrate and arrive at the wintering grounds later than females and immatures.

**Breeding Activities and Social Organization.** Adult kestrels are solitary, except during the breeding season, and maintain territories even in winter. Kestrels typically build their nests in tree cavities, but have used holes in telephone poles, buildings, or stream banks when tree cavities are not available. Both parents participate in incubation, but the female performs most of the incubation which usually lasts 29 to 31 days, while the male provides her with food. Following hatching, the male brings the majority of the prey to the nestlings. After fledging, young kestrels remain dependant on their parents for food for at least 2 to 4 additional weeks. Fledglings often perch and socialize with their siblings prior to dispersal.

**Home Range and Resources.** Although some investigators have not noted territorial defense, others have demonstrated that kestrels defend territories by introducing captured birds into other birds' territories. Winter foraging territories range from a few hectares in productive areas to hundreds of hectares in less productive areas. Summer breeding territories probably follow the same pattern.

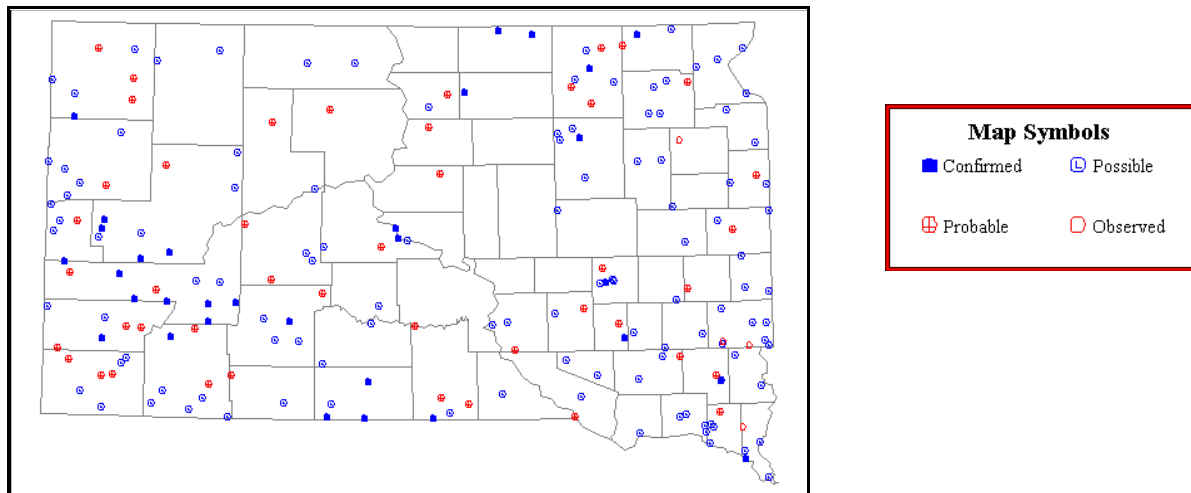
### Distribution of the American Kestrel in North America



BBS - Breeding Bird Survey. This survey is typically performed in June by volunteers on over 4000 bird counts. The counts are done by vehicle during the morning. Many nocturnal or less vocal species are not well surveyed by the BBS.

Source: Gough et al., 1998

### Distribution of the American Kestrel in South Dakota



Source: Peterson, 1995

**South Dakota Status.** Not identified as threatened or endangered by the state of South Dakota; common and widespread throughout the state.

---

References:

Gough, G.A., Sauer, J.R., Iliff, M. Patuxent Bird Identification Infocenter. 1998. Version 97.1. Patuxent Wildlife Research Center, Laurel, MD.

Available: <http://www.mbr-pwrc.usgs.gov/Infocenter/infocenter.html>

NatureServe: An online encyclopedia of life [web application]. 2001. Version 1.3 . Arlington, Virginia, USA: Association for Biodiversity Information.

Available: <http://www.natureserve.org/>

Over, William H. and Thomas, Craig S. 1946. Birds of South Dakota, Revised Edition. Natural History Studies, Number One. University of South Dakota Museum, Vermillion, South Dakota. January, 1946.

Peterson, Richard A. 1995. The South Dakota breeding bird atlas. South Dakota Ornithologists' Union. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page. (Version 06JUL2000).

Available: <http://www.npwrc.usgs.gov/resource/distr/birds/sdatlas/sdatlas.htm>

United States Environmental Protection Agency (USEPA). 1993. Wildlife Exposure Factors Handbook - Volume I of II. EPA/600/R-93/187a. Office of Research and Development. December 1993.

### **Red Fox (*Vulpes vulpes*)**

(text from USEPA, 1993)

**Order Carnivora, Family Canidae.** Red foxes are present throughout the United States and Canada except in the southeast, extreme southwest, and parts of the central states. Red fox prey extensively on mice and voles, but also feed on other small mammals, insects, game birds, and occasionally seeds, berries, and fruits. Twelve subspecies are recognized in North America.



**Body Size and Characteristics.** The dog-sized red fox has a body about 56 to 63 centimeters in length, with a long tail (35 to 41 centimeters). They weigh from 3 to 7 kilograms, with the males usually outweighing the females by about 1 kilogram. The red fox is usually recognized by its reddish coat, its white-tipped tail, and black “stockings,” although the species does have many color variations. The outside of the ears may be black-tipped, while the inside is usually white. The white tip on the tail will distinguish this fox from other species, regardless of its color phase.

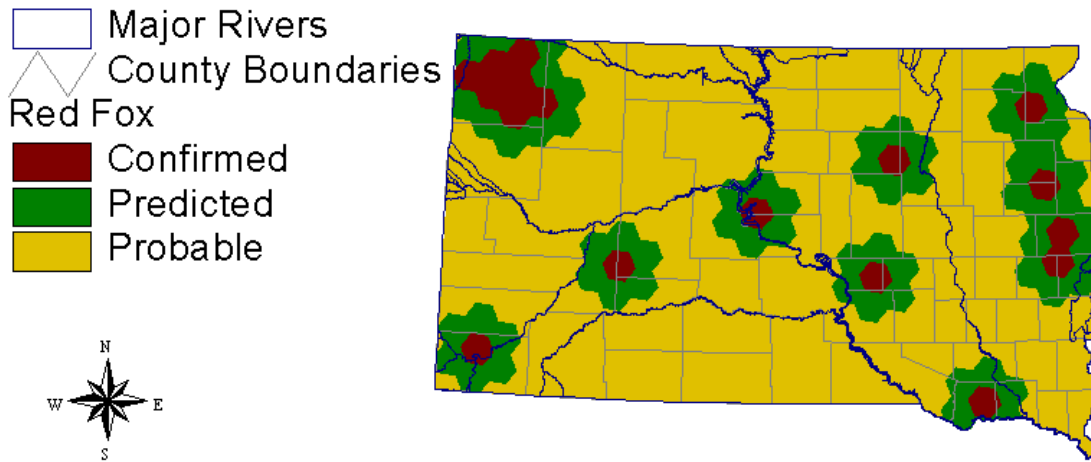
**Habitat.** As the most widely distributed carnivore in the world, the red fox can live in habitats ranging from arctic areas to temperate deserts. Red foxes utilize many types of habitat - cropland, rolling farmland, brush, pastures, hardwood stands, and coniferous forests. They prefer areas with broken and diverse upland habitats such as occur in most agricultural areas. They are rare or absent from continuous stands of pine forests in the southeast, moist conifer forests along the Pacific coast, and semiarid grasslands and deserts.

**Food Habits.** The red fox is an opportunistic carnivore that feeds mostly on small mammals, but will also eat birds, insects, and fruit. Meadow voles are a major food in most areas of North America; other common prey include mice and rabbits. Game birds and waterfowl are seasonally important prey in some areas. Plant material is most common in red fox diets in summer and fall when fruits, berries, and nuts become available. Red foxes often cache food in a hole for future use. They have also been noted scavenging on carcasses or other refuse. Most activity is nocturnal and a twilight.

**Breeding Activities and Social Organization.** Male and female foxes pair for life, remaining together from midwinter to summer. Red fox breeding occurs earlier in the south than in the northern ranges. The red fox's den is usually modified from an existing woodchuck or fox den. These scent-marked dens have multiple rooms, entrances, and trails leading to and from hunting areas within the territory. Females bear one litter per year usually between March and April, with litter sizes ranging between 4 to 6 pups. Gestation periods last from about 49 to 56 days; pups are born and reared in an underground den, and the male assists the female in rearing young, bringing food to the den for the pups. Pups first emerge from the den when about 4 to 5 weeks old and are typically weaned after 8 to 10 weeks. Once considered solitary, red foxes are now reported to exhibit more complex social habits. A fox family generally consists of a mated pair or one male and several related females (usually nonbreeders that often help the breeding female). Red fox have high mortality rates due to trapping, disease, shooting, and accidents (eg: roadkills).

**Home Range and Resources.** A mated pair maintains a territory throughout the year, with the male contributing more to its defense than the female. The home ranges of individuals from the same family overlap considerably, constituting a family territory. Territory sizes range from less than 50 to over 3,000 hectares. Territories in urban areas tend to be smaller than those in rural areas. Territory boundaries often conform to physical landscape features such as well-traveled roads and streams. Territory defense is primarily by nonaggressive mechanisms involving urine scent-marking and avoidance behaviors.

## Distribution of Red Fox in South Dakota



Source: SDSU, 2001.

---

### References:

- Alaska Department of Fish & Game (ADF&G). 2001. Juneau, Alaska, USA. ADF&G Wildlife Notebook Series. Available: <http://www.state.ak.us/local/akpages/FISH.GAME/notebook/notehome.htm>
- Barbour, R.W. and W.H. Davis. 1974. Mammals of Kentucky. Lexington, KY: University of Kentucky Press. 322p.
- Beyer, W.N., E.E. Conner, and S. Gerould. 1994. "Estimates of Soil Ingestion by Wildlife." J. Wildl. Manage., 58(2):375-382.
- Hoffmeister, D.F. 1989. Mammals of Illinois. Urbana, IL: University of Illinois Press. 348p.
- Jones, Jr., J.K.J. and E.C. Birney. 1988. Handbook of Mammals of the North Central States. Minneapolis, MN: University of Minnesota Press. 346p.
- Merritt, J.F. 1987. Guide to the Mammals of Pennsylvania. Pittsburgh, PA: University of Pittsburgh Press. 408p.
- Schwartz, C.W. and E.R. Schwartz. 1981. The Wild Mammals of Missouri, Revised Edition. Columbia, MO: University of Missouri Press and Missouri Dept. Conserv. 356p.
- South Dakota State University (SDSU). 2001. South Dakota Gap Analysis Project (SD-GAP). Conducted by the Department of Wildlife and Fisheries Sciences and South Dakota Cooperative Fish and Wildlife Research Unit as a part of the National Gap Analysis Program headed by the USGS, Biological Resources Division. Available at: <http://wfs.sdstate.edu/sdgap/mammal/redfox.html>.
- United States Environmental Protection Agency (USEPA). 1993. Wildlife Exposure Factors Handbook, Volume I of II. Office of Research and Development, Washington, D.C. EPA/600/R-93/187a.

<p style="text-align: center;"><b>Cliff Swallow</b> <i>Petrochelidon pyrchonota</i></p>				
Parameter	Symbol	Reported Values	References	Values Identified for ERA
<b>Habitat</b>		Found in open to semi-open land, farms, cliffs, river bluffs, and lakes. Nests in cliffs and barns.	Peterson, 1980	
<b>Body Weight</b> (kg)	BW	18.0-22.0g Adult  17.5-26.7g Adult	<a href="http://www.pacificwildlife.org">http://www.pacificwildlife.org</a> Dunning, 1993	Mean of reported values for adults:  0.021
<b>Food Ingestion Rate</b> (kg wet weight/day)	IR <sub>food</sub>	Specific values for the cliff swallow are unavailable. Estimated based on following equation: $IR_{\text{food}} (\text{kg dw/day}) = 0.0582 * BW (\text{kg ww})^{0.651}$	USEPA, 1993	Estimated from equation:  0.005
<b>Water Ingestion Rate</b> (L/day)	IR <sub>water</sub>	Specific values for the cliff swallow are unavailable. Estimated based on following equation $IR_{\text{water}} = 0.059 * BW^{0.67}$	USEPA, 1993	Estimated from equation:  0.004
<b>Soil Ingestion Rate</b> (kg dry weight/day)	IR <sub>soil</sub>	Specific soil ingestion values are not available for the cliff swallow. Because of burrowing in the banks of rivers or streams nature while constructing nests, soil ingestion is assumed to be 7% of the diet.	Assumption	A swallow will have a soil intake of 7%. $I_{\text{soil}} = 0.07$  $IR_{\text{soil}} = IR_{\text{food}} * 0.2 * I_{\text{soil}}$ Where 0.2 (kg food dry weight /kg food wet weight) = wet weight to dry weight conversion factor for food assuming 20% dry matter in food:  0.00007
<b>Dietary Composition</b> (fraction wet volume)	df	Nearly all of the diet consists of insects (terrestrial invertebrates) caught while flying.	<a href="http://www.mbr.nbs.gov">http://www.mbr.nbs.gov</a>	Terrestrial invertebrates = $df_{\text{terrinverts}} = 100\%$
<b>Home Range Size</b> (ha)	HR	No information available		No Info
<b>Seasonal Use</b>		Winters in Brazil, Argentina, and Chile. Summers in Alaska and Canada.	Peterson, 1980	

Meadow Vole <i>Microtus pennsylvanicus</i>				
Parameter	Symbol	Reported Values	References	Values Identified for ERA
Habitat		The meadow vole inhabits areas with dense vegetative cover including grassy fields, marshes, and bogs.	USEPA, 1993	
Body Weight (kg)	BW	40.0 +/- 8.3 SE - Mean - adult males in summer 33.4 +/- 8.2 SE - Mean - adult females in summer 52.4 - Mean - adult males in spring 43.5 - Mean - adult females in spring 26.0 - Mean - adult males and females in spring 24.3 - Mean - adult males and females in summer 17.0 - Mean - adult males and females in fall 17.5 - Mean - adult males and females in winter 35.5 +/- 0.1 SE - Mean - adult males all year 35.9 +/- 0.3 SE - Mean - adult males all year	USEPA, 1993	Mean of reported means: 0.033
Food Ingestion Rate (kg wet weight/day)	IR <sub>food</sub>	0.30 - 0.35 g/g/day - Mean - no sex reported  = 0.0098 kg/day (based on a BW of 0.033 kg)	USEPA, 1993	Reported value used:  0.0098
Water Ingestion Rate (L/day)	IR <sub>water</sub>	Specific values for the meadow vole are unavailable. Can be estimated based on the following equation: $IR_{water} = 0.099 * BW^{0.90}$	USEPA, 1993	Estimated from equation:  0.0045
Soil Ingestion Rate (kg dry weight/day)	IR <sub>soil</sub>	Specific soil ingestion values are not available for the meadow vole. Ingestion of soil (I <sub>soil</sub> ) as percentage of food intake (kg soil dry weight/kg food dry weight) is estimated at 13%.	Assumption	A meadow vole will have a soil intake of 13%. I <sub>soil</sub> = 0.13  IR <sub>soil</sub> = IR <sub>food</sub> * 0.32 * I <sub>soil</sub> . Where 0.32 (kg food dry weight /kg food wet weight) = wet weight to dry weight conversion factor for food assuming 32% dry matter in food:  0.00041 32% solids in diet based on weighted average.
Dietary Composition (fraction wet volume)	df	The meadow vole primarily feeds on monocot and dicot shoots, seeds, roots, fungi, and grasses. Some individuals have been reported to eat insects and worms.	USEPA, 1993	Fraction soil invertebrates = d <sub>soilinverts</sub> = 5% Fraction terr invertebrates = df <sub>terrinverts</sub> = 5% Fraction plants = df <sub>plant</sub> = 90%
Home Range Size (ha)	HR	0.019 +/- 0.011 SD - Mean - adult males in summer - Virginia/old field 0.0069 +/- 0.0039 SD - Mean - adult females in summer - Virginia/old 0.014 - Mean - adult males and females in summer - Montana/alluvial 0.0002 - Mean - adult males and females in winter - Montana/alluvial 0.083 +/- 0.037 SD - Mean - adult males in summer - 0.037 +/- 0.020 SD - Mean - adult females in summer - Massachusetts/grassy meadow	USEPA, 1993	Mean of reported values: 0.027
Seasonal Use		No information available.		No Info

<p style="text-align: center;"><b>Red Fox</b> <i>Vulpes vulpes</i></p>				
Parameter	Symbol	Reported Values	References	Values Identified for ERA
<b>Habitat</b>		Habitats are diverse. Red fox prefer areas with broken and diverse upland habitats. Inhabit open meadows, ditch banks, field and wood edges, farmlands, fence rows, and stream/lake borders. They are rare in pine forests, moist conifer forests and semiarid grasslands and deserts.	USEPA, 1993	
<b>Body Weight</b> (kg wet weight)	BW	5.25 - Mean - adult males in spring - Illinois 4.13 - Mean - adult females in spring - Illinois 4.82 - Mean - adult males in fall - Iowa 3.94 - Mean - adult females in fall - Iowa 2.95 to 7.04 - Range of means	USEPA, 1993	Mean of reported means: 4.54
<b>Food Ingestion Rate</b> (kg wet weight/day)	IR <sub>food</sub>	0.069 g/g-day (wet weight) - Mean - nonbreeding adults - North Dakota - captive = 0.31 kg/day (based on BW of 4.54 kg)	USEPA, 1993	Reported value used:  0.31
<b>Water Ingestion Rate</b> (L/day)	IR <sub>water</sub>	Specific values for the red fox are unavailable. Can be estimated based on the following equation: $IR_{water} = 0.099 * BW^{0.90}$	USEPA, 1993	Estimated from equation: 0.39
<b>Soil Ingestion Rate</b> (kg dry weight/day)	IR <sub>soil</sub>	Ingestion of soil (I <sub>soil</sub> ) as percentage of food intake (kg sediment dry weight/kg food dry weight) is reported at 2.8%. I <sub>sed</sub> equal to 0.028.	Beyer, 1994	IR <sub>soil</sub> = IR <sub>food</sub> * 0.27 * I <sub>soil</sub> . Where 0.27 (kg food dry weight /kg food wet weight) = wet weight to dry weight conversion factor for food assuming 27% dry matter in food: 0.0023 27% solids in diet based on weighted average.
<b>Dietary Composition</b>  (fraction wet volume)	df	The red fox feeds on both plants and animals with most of its diet composed of small mammals (eg: rabbits, rodents, skunks, muskrats), birds, insects and fruit.	USEPA, 1993	Fraction mammals= df <sub>mammals</sub> = 90% Fraction plants = df <sub>plant</sub> = 10%
<b>Home Range Size</b> (ha)	HR	1,611 - Mean -adult both sexes - British Columbia 1,967 - Mean - adult male - British Columbia 1,137 - Mean - adult female - British Columbia 699 - Mean - adult female - spring - Minnesota 717 - Mean - adult male - Wisconsin 96 - Mean - adult female - Wisconsin	USEPA, 1993	Mean of reported values: 1,038
<b>Seasonal Use</b>		No information available.		No Info

<p style="text-align: center;"><b>Masked Shrew</b> <i>Sorex cinereus</i></p>				
Parameter	Symbol	Reported Values	References	Values Identified for ERA
<b>Habitat</b>		Masked shrews are the most common shrews in moist forests, open country, and brush of the northern United States. High-metabolic rates require cool, moist areas such as low damp areas in stream valleys or floodplains.	Zeveloff, 1988	
<b>Body Weight</b> (kg wet weight)	BW	2.4-7.8 g (mean of range = 5.1g) 4-7g (mean of range = 5.5g)	Whitaker, 1980 Burt & Grossenheider, 1976	Mean of reported means: 0.0053
<b>Food Ingestion Rate</b> (kg wet weight/day)	IR <sub>food</sub>	0.00795 - Mean - adults both sexes - Ohio laboratory 0.62 g/g- day = 0.01 kg/d = Mean - adults both sexes - Ohio lab	USEPA, 1993 <sup>a</sup>	Mean of mean values: 0.0090
<b>Water Ingestion Rate</b> (L/day)	IR <sub>water</sub>	Can be estimated based on the following equation: Can be estimated based on the following equation: $IR_{water} = 0.099 \cdot BW^{0.90}$	USEPA, 1993	Estimated from equation:  0.00089
<b>Soil Ingestion Rate</b> (kg dry weight/day)	IR <sub>soil</sub>	Ingestion of soil (I <sub>soil</sub> ) as percentage of food intake (kg soil dry weight/kg food dry weight) is reported at 13%. Value reported for short-tail shrew.	Talmage & Walton, 1993 <sup>a</sup>	$IR_{soil} = IR_{food} \cdot 0.32 \cdot I_{soil}$ . Where 0.32 (kg food dry weight /kg food wet weight) = wet weight to dry weight conversion factor for food assuming 32% dry matter in food:  0.00037 32% solids in diet based on weighted average.
<b>Dietary Composition</b> (fraction wet volume)	df	The masked shrew is primarily feeds on insects with beetles, flies, and ants comprising most of their diet. Diet consists of butterflies, moths, beetle larvae, slugs, snails, and spiders; seldom eat worms or vegetable matter.	Zeveloff, 1988	Fraction soil invertebrates = $d_{soilinverts} = 50\%$ Fraction terr invertebrates = $df_{terrinvets} = 50\%$
<b>Home Range Size</b> (ha)	HR	0.39 - Mean - both sexes - Manitoba bog	USEPA, 1993 <sup>a</sup>	Reported mean selected: 0.39
<b>Seasonal Use</b>		No information available.		No Info

<sup>a</sup> uses values established for the short-tailed shrew

<p style="text-align: center;"><b>Deer Mouse</b> <i>Peromyscus maniculatus</i></p>				
Parameter	Symbol	Reported Values	References	Values Identified for ERA
<b>Habitat</b>		Deer mice inhabit all types of dry-land type habitats including short-grass prairies, grass-sage communities, coastal sage scrub, sand dunes, wet prairies, upland mixed and cedar forests, and deciduous forests.	USEPA, 1993	
<b>Body Weight</b> (kg wet weight)	BW	0.022 - Mean - adult males - North America 0.020 - Mean - adult females - North America 0.0157 - Mean - adult males 0.0148 - Mean - adult females 0.0223 - Mean - adult males 0.0211 - Mean - adult females 0.0196 - Mean - both sexes - New Hampshire	USEPA, 1993	Mean of reported means:  0.019
<b>Food Ingestion Rate</b> (kg wet weight/day)	IR <sub>food</sub>	0.19 g/g-day (wet weight) - Mean - adult females - Canada 0.18 g/g-day (wet weight) - Mean - adult females - Canada 0.45 g/g-day - Mean - lactating females - Canada 0.38 g/g-day - Mean - lactating females - Canada 0.19 g/g-day - Mean - nonbreeding females - Virginia lab 0.22 g/g-day - Mean - nonbreeding males - Virginia lab	USEPA, 1993	Mean of reported mean values (0.268 g/g-day) for free-living adults is used converting to kg/day based on a BW of 0.019 kg:  0.005
<b>Water Ingestion Rate</b> (L/day)	IR <sub>water</sub>	0.19 g/g-day - Mean -adults - Illinois lab Can be estimated based on the following equation: $IR_{water} = 0.099 * BW^{0.90}$	USEPA, 1993	Estimated based on equation:  0.0028
<b>Soil Ingestion Rate</b> (kg dry weight/day)	IR <sub>soil</sub>	Ingestion of soil (I <sub>soil</sub> ) as percentage of food intake (kg soil dry weight/kg food dry weight) is not available for the deer mouse. Beyer reports <2% for the white-footed mouse. It is assumed that the deer mouse is similar due to a similar diet <sub>soil</sub> is assumed to equal 0.02 or 2% of food intake.	Beyer, 1994	$IR_{soil} = IR_{food} * 0.55 * I_{soil}$ Where 0.55 (kg food dry weight /kg food wet weight) = wet weight to dry weight conversion factor for food assuming 55% dry matter in food:  0.00006
<b>Dietary Composition</b> (fraction wet volume)	df	Deer mice are omnivorous and opportunistic. They eat primarily seeds, arthropods, some green vegetation, roots, fruits and fungi. In Colorado short grass prairie, the reported diet contains: 43% seeds, 5.4% forbs, 3.6% grasses and sedges, 2.1% shrubs, 13% beetles, 4.9% leafhoppers, 9.4% lepidopterans, and 2.0% spiders.	USEPA, 1993	Fraction plants = df <sub>plant</sub> = 90% Fraction terrestrial invertebrates = df <sub>terrinvert</sub> = 5% Fraction soil invertebrates = df <sub>soilinvert</sub> = 5%
<b>Home Range Size</b> (ha)	HR	The home range of female deer mice encompass both their foraging areas and their nests. Male home ranges are larger and overlap those of the females. 0.039 - Mean for adult males in summer in Utah subalpine meadow 0.027 - Mean for adult females in summer in Utah subalpine meadow 0.10 - Mean for adult males in Oregon ponderosa pines 0.075 - Mean for adult females in Oregon ponderosa pines 0.128 - Mean for adult males in Idaho desert 0.094 - Mean for adult females in Idaho desert	USEPA, 1993	Mean of means for females:  0.065
<b>Seasonal Use</b>		Torpor reported in winter in northern parts of range.	USEPA, 1993	

<p style="text-align: center;"><b>Mink</b> <i>Mustela vison</i></p>				
Parameter	Symbol	Reported Values	References	Values Identified for ERA
<b>Habitat</b>		Mink are associated with aquatic habitats including rivers, streams, lakes, ditches, swamps, marshes and backwater areas. They prefer irregular shorelines and brushy or wooded cover adjacent to the water.	USEPA, 1993	
<b>Body Weight</b> (kg wet weight)	BW	1.04 - Mean - adult male - summer - Montana 1.233 - Mean - adult male - fall - Montana 0.550 - Mean - adult female- summer - Montana 0.586 - Mean - adult female - fall - Montana 0.777 - Mean - juvenile male - summer - Montana 0.533 - Mean - juvenile female - summer - Montana	USEPA, 1993	Mean of means for females: 0.556
<b>Food Ingestion Rate</b> (kg wet weight/day)	IR <sub>food</sub>	0.13 g/g-day - Mean - captive males = 0.15 kg/day (using 1.14 kg BW) 0.12 g/g-day - Mean - farm raised males = 0.14 kg/day 0.16 g/g-day - Mean - farm raised females = 0.089 kg/day (0.556 BW)	USEPA, 1993	Mean of means for females: 0.089
<b>Water Ingestion Rate</b> (L/day)	IR <sub>water</sub>	0.028 g/g-day = 0.022 L/day - Mean for farm raised mink.	USEPA, 1993	Reported mean selected: 0.0584
<b>Sediment Ingestion Rate</b> (kg dry weight/day)	IR <sub>sediment</sub>	Sediment ingestion rates for the mink are not available. Ingestion of sediment (I <sub>sed</sub> ) as percentage of food intake (kg dry weight/kg food dry weight) is assumed to be equal to 1%.	Assumption	$IR_{sed} = IR_{food} * 0.25 * I_{sed}$ where 0.25 (kg food dry weight /kg food wet weight) = wet weight to dry weight conversion factor for food assuming 25% dry matter in food: 0.0002
<b>Dietary Composition</b> (fraction wet volume)	df	Mink are opportunistic feeders taking whatever prey is abundant. In many parts of its range mammals are the most important prey but mink hunt aquatic prey as well depending on the season.  In mink intestines collected from Montana, percent frequency of occurrence in samples for food items: 61.5% fish; 19.2% mammals and 26.9% aquatic invertebrates. In mink stomachs, the frequency of occurrence was: 11.5% fish, and 7.2% mammals.	USEPA, 1993  RCG, Hagler Bailly, 1995	Fraction fish= df <sub>fish</sub> = 60% Fraction aquatic invertebrates = df <sub>aquainverts</sub> = 20% Fraction mammals = df <sub>mammal</sub> = 20%
<b>Home Range Size</b> (ha)	HR	Range size and shape depends on habitat. Shape is linear along streams and circular in marshes. Montana /riverine: 7.8 - Female mink in heavy vegetation 20.4 - Female mink in sparse vegetation	USEPA, 1993	Mean of reported values: 14.1
<b>Seasonal Use</b>		Mink are nocturnal and active year round.	USEPA, 1993	

<p style="text-align: center;"><b>American Robin</b> <i>Turdus migratorius</i></p>				
Parameter	Symbol	Reported Values	References	Values Identified for ERA
<b>Habitat</b>		Breeds in moist forests, swamps, open woodlands, orchards, parks, and lawns. Forages on ground in open areas along habitat edges of streams.	USEPA, 1993; Sample & Suter, 1994	
<b>Body Weight</b> (kg wet weight)	BW	0.0773 - Mean - adults - Pennsylvania 0.0862 - Mean - adult male nonbreeders - New York 0.0836 - Mean - adult female nonbreeders - New York 0.0774 - Mean - adult female breeders -New York 0.0806 - Mean - adult male breeders - New York 0.0635 to 0.103 - Range breeding adults - PA (median=0.0833)	USEPA, 1993	Mean of reported means for breeding adults:  0.0814
<b>Food Ingestion Rate</b> (kg wet weight/day)	IR <sub>food</sub>	0.89 g/g-day (wet weight) - Mean - breeding free living male and females - California = 0.0698 kg/day (BW = 0.0823 kg) 1.52 g/g-day (wet weight) - Mean - free living adults - Kansas = 0.12 kg/day (BW = 0.055 kg)	USEPA, 1993	Mean of two reported values:  0.078
<b>Water Ingestion Rate</b> (L/day)	IR <sub>water</sub>	Specific values for the American robin are unavailable. Estimated based on following equation $IR_{water} = 0.059 * BW^{0.67}$	USEPA, 1993	Estimated from equation:  0.011
<b>Soil Ingestion Rate</b> (kg dry weight/day)	IR <sub>soil</sub>	Specific soil ingestion values are not available for the American robin. If soil ingestion is assumed to be proportional to the fraction of earthworms (soil invertebrates) in the diet, then the reported soil ingestion for the American woodcock can be used as a basis for deriving a value for the American robin.  If the diet of the woodcock is 99% earthworms and 10.4% of their diet is soil then a robin consuming 77% earthworms will consume 8.1% soil. $I_{soil} = 0.081$	Beyer, 1994; Sample & Suter, 1994	$IR_{sed} = IR_{food} * 0.2 * I_{sed}$ Where 0.2 (kg food dry weight /kg food wet weight) = wet weight to dry weight conversion factor for food assuming 20% dry matter in food:  0.0012
<b>Dietary Composition</b> (fraction wet volume)	df	Western United States Spring: fruit 17%; invertebrates 83% Summer: fruit 29%; invertebrates 71% Fall: fruit 63%; invertebrates 37% Winter: fruit 70%; invertebrates 30%	USEPA, 1993	Diet reported for breeding season used (spring & summer). Reported fractions for seasons are averaged: Fraction plants = $df_{plants} = 23\%$ Fraction soil invertebrates = $df_{soilinverts} = 77\%$
<b>Home Range Size</b> (ha)	HR	Foraging home range from nests in summer 0.15 - Mean - adults with nestling 0.81 - Mean - adults with fledgling	USEPA, 1993	Mean of mean values:  0.48
<b>Seasonal Use</b>		Migratory in northern portion of range. Leave breeding grounds from September to November returning from February to April.	USEPA, 1993	

**American Kestrel**  
*Falco sparverius*

Parameter	Symbol	Reported Values	References	Values Identified for ERA
<b>Habitat</b>		Open deserts, semi-open areas, edges of groves and urban areas	USEPA, 1993	
<b>Body Weight</b> (kg wet weight)	BW	0.115 - Mean - females - fall - Californi 0.103 - Mean - males - fall - Californi 0.124 - Mean - laying females - Utah 0.127 - Mean - females - fall - Utah 0.108 - Mean - incubating males - Utah 0.111 - Mean - males - fall - Utah	USEPA, 1993	Mean of reported means:  0.115
<b>Food Ingestion Rate</b> (kg wet weight/day)	IR <sub>food</sub>	0.29 g/g -day (wet weight) - Mean - free-living adults - winter - California 0.31 g/g-day (wet weight) - seminatural enclosed adults - Ohio	USEPA, 1993	Reported mean value for free-living adults is used:  0.033
<b>Water Ingestion Rate</b> (L/day)	IR <sub>water</sub>	Species specific values are not available. Estimated based on following equation $IR_{water} = 0.059 * BW^{0.67}$	USEPA, 1993	Estimated from equation:  0.014
<b>Soil Ingestion Rate</b> (kg dry weight/day)	IR <sub>soil</sub>	Ingestion of soil (I <sub>soil</sub> ) as percentage of food intake (kg soil dry weight/kg food dry weight) is not available. Assumed to be equal to 1%.	Assumption	IR <sub>soil</sub> = IR <sub>food</sub> *0.33*I <sub>soil</sub> Where 0.33 (kg food dry weight /kg food wet weight) = wet weight to dry weight conversion factor for food assuming 33% dry matter in food:  0.0001 33% solids in diet based on weighted average
<b>Dietary Composition</b> (fraction wet volume)	df	Kestrels prey on a variety of small animals including invertebrates(worms, spiders, scorpions, beetles), amphibians, reptiles and small to medium-sized birds and mammals. Reported diet in California open areas: Invertebrates: 32.6%, mammals: 31.7%, birds: 30.3%, reptiles: 1.9 %, and other 3.5%.	USEPA, 1993	Fraction terr. invertebrates = df <sub>terrinverts</sub> = 33% Fraction mammals = df <sub>mammals</sub> = 67% (Fraction mammals includes bird fraction)
<b>Home Range Size</b> (ha)	HR	202 - Mean - adults - summer - Wyoming 131- Mean - adults - summer - Michigai 21 to 500 - Range for summer 9.7 to 42 - Range for winter	USEPA, 1993	Mean of reported means for summer 167
<b>Seasonal Use</b>		The American Kestrel is a year-round resident over most of the United States; but is migratory in the northern-most portion of its range. In Utah the American Kestrel migrates in early September to early November and in Wyoming it returns in mid-April.	USEPA, 1993	

<p style="text-align: center;"><b>Belted King Fisher</b> <i>Ceryle alcyon</i></p>				
Parameter	Symbol	Reported Values	References	Values Identified for ERA
<b>Habitat</b>		Forages on ground in open areas along habitat edges of streams, rivers ponds and lakes where fish concentrations are greatest. Nests in burrows that are devoid of vegetation.	USEPA, 1993	
<b>Body Weight</b> (kg wet weight)	BW	0.148kg - Mean - adults - Pennsylvania 0.136kg - Mean - adults - Pennsylvania 0.158kg - Mean - adults - Ohio	USEPA, 1993	Mean of reported means: 0.147
<b>Food Ingestion Rate</b> (kg wet weight/day)	IR <sub>food</sub>	0.5 g/g-day - Mean - adults - northcentral lower Michigan  (food ingestion rate calculated using a body weight of 0.147kg)	USEPA, 1993	Reported value: 0.0735
<b>Water Ingestion Rate</b> (L/day)	IR <sub>water</sub>	Species specific values not available. Estimated based on following equation: $IR_{water} = 0.059 * BW^{0.67}$	USEPA, 1993	Estimated from equation: 0.016
<b>Sediment Ingestion Rate</b> (kg dry weight/day)	IR <sub>sed</sub>	Ingestion of sediment (I <sub>sed</sub> ) as percentage of food intake (kg dry weight/kg food dry weight) is not available. Because of burrowing in the banks of rivers or streams nature while constructing nests, soil ingestion is assumed to be 2% of the diet. I <sub>sed</sub> = 0.02  Ingestion assumption based on 9.6% sediment ingestion by bluegill (Kolehmainen, 1974).	Assumption	IR <sub>sed</sub> = IR <sub>food</sub> *0.27*I <sub>sed</sub> Where 0.27 (kg food dry weight /kg food wet weight) = wet weight to dry weight conversion factor for food assuming 27% dry matter in food: 0.0004
<b>Dietary Composition</b> (fraction wet volume)	df	Michigan/trout streams: Trout: 30% Game fish: 13% Forage fish: 15% Unidentified fish: 1% Crayfish: 41% Invertebrates: <1% (up to 19% in spring and fall)	USEPA, 1993	Fraction fish = df <sub>fish</sub> = 90% Fraction aquatic invertebrates = df <sub>aquainverts</sub> = 10%
<b>Home Range Size</b> (ha)	HR	During the spring and early summer the breeding pairs defend both the territory including both their nest site and their foraging area. By autumn each bird defends an individual feeding territory only. Breeding territories can be more than twice as long as the feeding territory. Foraging territory is inversely related to prey abundance.	USEPA, 1993	No Info
<b>Foraging Distance</b> (km)		Foraging distance in early summer (breeding pairs): 2.19 - Mean - Pennsylvania 1.03 - Mean - Ohio/streams 1.03 - Mean - southwest Ohio/streams	USEPA, 1993	Mean of means for breeding pairs: 1.42
<b>Seasonal Use</b>		Migratory in northern portion of range. Leave breeding grounds from October to December returning from February to April.	USEPA, 1993	

Great Horned Owl <i>Bubo virginianus</i>				
Parameter	Symbol	Reported Values	References	Values Identified for ERA
Habitat		Woodlands including stream-bottom forests in the praries and pine forests in the black hills.	SDOU, 1991	
Body Weight (kg)	BW	985 - 1588 g Male adult 1417 - 2503 g Female adult	Dunning, 1993	Mean of reported values for adults:  1.62
Food Ingestion Rate (kg wet weight/day)	IR <sub>food</sub>	0.082 kg/day	Earheart and Johnson, 1970; Nichols and Warrier, 1972	Reported value:  0.082
Water Ingestion Rate (L/day)	IR <sub>water</sub>	Specific values for the great horned owl are unavailable. Estimated based on following equation $IR_{water} = 0.059 * BW^{0.67}$	USEPA, 1993	Estimated from equation:  0.082
Soil Ingestion Rate (kg dry weight/day)	IR <sub>soil</sub>	Specific soil ingestion values are not available for the great horned owl. Soil ingestion is assumed to be 2% of the diet.	Assumption	A great horned owl will have a soil intake of 2%. $I_{soil} = 0.02$  $IR_{soil} = IR_{food} * 0.2 * I_{soil}$ Where 0.2 (kg food dry weight /kg food wet weight) = wet weight to dry weight conversion factor for food assuming 20% dry matter in food:  0.00033
Dietary Composition (fraction wet volume)	df	Diet consists primarily of small mammals such as shrews, rabbits, and squirrels, chipmunks, rats, mice, gophers, opossums; will also eat reptiles, frogs and fish.	Terres, 1991	Dietary fractions not available. Values are assumed.  Fraction mammals = $df_{mammal} = 95\%$ Fraction fish = $df_{fish} = 5\%$
Home Range Size (ha)	HR	No information available		No Info
Seasonal Use		Found throughout North America and also Central and South America year round.	Terres, 1991	

<p style="text-align: center;"><b>American Dipper</b> <i>Cinclus mexicanus</i></p>				
Parameter	Symbol	Reported Values	References	Values Identified for ERA
<b>Habitat</b>		Found near swift mountain streams.	SDOU, 1991	
<b>Body Weight</b> (kg)	BW	0.0546 - 0.061kg	Dunning, 1993	Mean of reported values for adults:  0.058
<b>Food Ingestion Rate</b> (kg wet weight/day)	IR <sub>food</sub>	Specific values for the American dipper are unavailable. Estimated based on following equation: $IR_{\text{food}} (\text{kg dw/day}) = 0.0582 * BW (\text{kg ww})^{0.651}$	USEPA, 1993	Estimated from equation:  0.009
<b>Water Ingestion Rate</b> (L/day)	IR <sub>water</sub>	Specific values for the American dipper are unavailable. Estimated based on following equation $IR_{\text{water}} = 0.059 * BW^{0.67}$	USEPA, 1993	Estimated from equation:  0.009
<b>Sediment Ingestion Rate</b> (kg dry weight/day)	IR <sub>sed</sub>	Specific sediment ingestion values are not available for the American dipper. Sediment ingestion is assumed to be 2% of the diet.	Assumption	A swallow will have a soil intake of 2%. $I_{\text{soil}} = 0.02$  $IR_{\text{soil}} = IR_{\text{food}} * 0.2 * I_{\text{soil}}$ Where 0.2 (kg food dry weight /kg food wet weight) = wet weight to dry weight conversion factor for food assuming 20% dry matter in food:  0.00004
<b>Dietary Composition</b> (fraction wet volume)	df	Diet consists primarily of aquatic insects; also can include worms, and beetle	Terres, 1991	Aquatic invertebrates = $df_{\text{aquinverts}} = 100\%$
<b>Home Range Size</b> (ha)	HR	No information available		No Info
<b>Seasonal Use</b>		Does not migrate but moves to lower altitudes in fall	Terres, 1991	

## References for Wildlife Exposure Factors

- Beyer, W.N., Conner, E.E., Gerould, S. 1994. *Estimates of soil ingestion by wildlife*. J. Wildl. Manage. 58:375-382
- Burt, W.H. and R.P. Grossenheider. 1976. *Mammals (Peterson Field Guides) 3<sup>rd</sup> Edition*. Houghton Mifflin Company, Boston, Massachusetts.
- Dunning, J.B. 1993. *CRC Handbook of Avian Body Masses*. CRC Press, Inc., Boca Raton, Florida.
- Pacific Wildlife. 2000. Website devoted to preserving wildlife.  
[www.pacific.org](http://www.pacific.org)
- Peterson, R. T.. 1980. *Peterson Field Guides: Eastern Birds*. Houghton Mifflin Company, Boston, Massachusetts.
- RCG/Hagler Bailly. 1995. *Terrestrial Resources Injury Assessment Report, Upper Clark Fork River NPL Sites*. State of Montana Natural Resource Damage Program. January 1995.
- Sample, B. E. and G. W. Suter. 1994. *Estimating Exposure of Terrestrial Wildlife to Contaminants*. Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee. ES/ER/TM-125
- Talmage, S. and B. Walton. 1993. Food chain transfer and potential renal toxicity to small mammals at a contaminated terrestrial field site. *Ecotoxicology*. 2: 243-256.
- Terres, J.K. 1980. *The Audubon Society Encyclopedia of North American Birds*. Wings Books, New York, New York.
- The South Dakota Ornithologists' Union. 1991. *The Birds of South Dakota*. NSU Press, Aberdeen, SD. [SDOU, 199]
- USEPA. 1993. *Wildlife Exposure Factors Handbook*. Volume 1 and 2. Office of Research and Development, U.S. Environmental Protection Agency, EPA/600/R-93/187a and b. Washington, D.C.
- USGS – Patuxent Wildlife Research Center. 2000. Website devoted to bird population Research. [www.mbr.nbs.gov](http://www.mbr.nbs.gov)
- Whitaker, J.O 1980. *The Audobon Society Field Guide to North American Mammals*. Published by Alfred A. Knopf, Inc. Chanticleer Press, Inc., New York.
- Zeveloff, S.I. 1988. *Mammals of the Intermountain West*. University of Utah Press, Salt Lake City, Utah.

## **APPENDIX C**

### **SUMMARY OF THE SELECTION OF CHEMICALS OF POTENTIAL CONCERN**

**Appendix C.1**  
**Selection of Surface Water COPCs for Aquatic Receptors**

Parameter	Number of Detections	Number of Samples	Detection Frequency (DF)	Mean Detected Conc (ug/L)	Maximum Detected Conc (ug/L)	Mean Non- Detected Conc (ug/L)	Maximum Non- Detected Conc (ug/L)	AWQC Benchmark (ug/L)	Does cmpd have an TRV?	Is DF > 5%?	Is Mean DL < Benchmark?	Is Max Detect > Benchmark?	Qual Type 1	Qual Type 2	Quant COPC	Not a COPC
Aluminum	113	174	65%	19	90	6.6	15	87	yes	yes	yes	yes	0	0	1	0
Antimony	125	174	72%	4.2	13	2.6	15	na	no	yes	yes	no	1	0	0	0
Arsenic	204	220	93%	25	81	2.3	3	150	yes	yes	yes	no	0	0	0	1
Barium	99	174	57%	40	75	30	40	na	no	yes	yes	no	1	0	0	0
Beryllium	62	165	38%	0.6	1.5	0.30	0.7	na	no	yes	yes	no	1	0	0	0
Boron	62	106	58%	96	140	49	70	na	no	yes	yes	no	1	0	0	0
Cadmium	8	233	3%	2.0	8.0	0.64	5.0	0.45	yes	no	no	yes	0	1	0	0
Calcium	174	174	100%	106,136	185,000	na	na	na	no	yes	no	no	1	0	0	0
Chromium	43	220	20%	4.5	5	3.1	10	152	yes	yes	yes	no	0	0	0	1
Cobalt	82	174	47%	4.8	15.0	2.5	6.0	na	no	yes	yes	no	1	0	0	0
Copper	77	233	33%	7.7	30	4.8	5.0	17	yes	yes	yes	yes	0	0	1	0
Iron	90	174	52%	39	271	17	285	1,000	yes	yes	yes	no	0	0	0	1
Lead	59	233	25%	10.2	40	3.2	10	7.7	yes	yes	yes	yes	0	0	1	0
Lithium	153	159	96%	23	40	5.6	12	na	no	yes	yes	no	1	0	0	0
Magnesium	174	174	100%	49,786	80,300	na	na	na	no	yes	no	no	1	0	0	0
Manganese	137	174	79%	101	788	22	75	na	no	yes	yes	no	1	0	0	0
Mercury	23	232	10%	0.10	0.20	0.07	0.50	0.77	yes	yes	yes	no	0	0	0	1
Molybdenum	53	174	30%	9.3	21	5.8	20	na	no	yes	yes	no	1	0	0	0
Nickel	63	233	27%	6.9	10	5.9	15	94	yes	yes	yes	no	0	0	0	1
Phosphorus	90	92	98%	86	350	47	93	na	no	yes	yes	no	1	0	0	0
Potassium	106	106	100%	9,653	16,000	na	na	na	no	yes	no	no	1	0	0	0
Selenium	158	174	91%	2.6	9.0	0.63	1.0	5.0	yes	yes	yes	yes	0	0	1	0
Silica	159	159	100%	7,708	14,000	na	na	na	no	yes	no	no	1	0	0	0
Silver	16	233	7%	3.1	30	1.5	20	13	yes	yes	yes	yes	0	0	1	0
Sodium	174	174	100%	48,793	91,900	na	na	na	no	yes	no	no	1	0	0	0
Strontium	85	159	53%	681	1,060	210	400	na	no	yes	yes	no	1	0	0	0
Thallium	0	15	0%	na	na	2.6	3.0	na	no	no	yes	no	1	0	0	0
Uranium	16	23	70%	2.7	4.0	1.1	1.6	na	no	yes	yes	no	1	0	0	0
Vanadium	65	174	37%	5.2	10	2.5	5.0	na	no	yes	yes	no	1	0	0	0
Zinc	108	229	47%	7	40	6	20	216	yes	yes	yes	no	0	0	0	1
Cyanide, WAD	151	246	61%	28	98	4.4	5.0	5.2	yes	yes	yes	yes	0	0	1	0

Surface water concentrations used in the COPC screen are based on dissolved analysis, except cyanide which is based on weak acid dissociable (WAD).

**Total**                      **18**                      **1**                      **6**                      **6**

**Appendix C.2**  
**Selection of Surface Water COPCs for Wildlife Receptors**

Parameter	Number of Detections	Number of Samples	Detection Frequency (DF)	Mean Detected Conc (ug/L)	Maximum Detected Conc (ug/L)	Mean Non- Detected Conc (ug/L)	Maximum Non- Detected Conc (ug/L)	Wildlife Ingestion Benchmark (ug/L)	Is cmpd essential nutrient? <sup>a</sup>	Does cmpd have an TRV?	Is DF > 5%?	Is Mean DL < Benchmark?	Is Max Detect > Benchmark?	Qual Type 1	Qual Type 2	Quant COPC	Not a COPC
Aluminum	14	16	88%	399	1,510	13	13	4,474	no	yes	yes	yes	no	0	0	0	1
Antimony	1	16	6%	6.6	6.6	5.4	15	na	no	no	yes	yes	no	1	0	0	0
Arsenic	492	556	88%	49	3,100	2.5	2.5	292	no	yes	yes	yes	yes	0	0	1	0
Barium	16	16	100%	44	79	na	na	23,100	no	yes	yes	no	no	0	0	0	1
Beryllium	0	16	0%	na	na	0.50	0.50	na	no	no	no	yes	no	1	0	0	0
Boron	16	16	100%	79	127	na	na	124,000	no	yes	yes	no	no	0	0	0	1
Cadmium	122	554	22%	2.5	122	0.57	5.0	4,132	no	yes	yes	yes	no	0	0	0	1
Calcium	16	16	100%	125,688	180,000	na	na	na	yes	no	yes	no	no	0	0	0	1
Chromium	201	525	38%	12	216	2.9	48	4,300	no	yes	yes	yes	no	0	0	0	1
Cobalt	12	16	75%	4.3	9.0	2.5	4.5	7,670	no	yes	yes	yes	no	0	0	0	1
Copper	381	559	68%	22	690	3.7	10	65,200	no	yes	yes	yes	no	0	0	0	1
Iron	165	170	97%	5,553	330,000	171	495	na	no	no	yes	yes	no	1	0	0	0
Lead	189	556	34%	15	540	2.0	5.0	4,860	no	yes	yes	yes	no	0	0	0	1
Lithium	0	0	na	na	na	na	na	40,300	no	yes	no	no	yes	0	1	0	0
Magnesium	16	16	100%	52,331	72,200	na	na	na	yes	no	yes	no	no	0	0	0	1
Manganese	170	171	99%	386	20,000	5.0	5.0	377,000	no	yes	yes	yes	no	0	0	0	1
Mercury	121	558	22%	0.31	3.0	0.10	0.5	28	no	yes	yes	yes	no	0	0	0	1
Molybdenum	10	16	63%	4.9	9.4	1.8	3.0	600	no	yes	yes	yes	no	0	0	0	1
Nickel	233	470	50%	13	320	4.0	20	171,360	no	yes	yes	yes	no	0	0	0	1
Phosphorus	0	0	na	na	na	na	na	na	no	no	no	no	no	1	0	0	0
Potassium	16	16	100%	7,093	12,100	na	na	na	yes	no	yes	no	no	0	0	0	1
Selenium	125	169	74%	2.4	10	1.2	2.5	857	no	yes	yes	yes	no	0	0	0	1
Silica	0	0	na	na	na	na	na	na	no	no	no	no	no	1	0	0	0
Silver	304	558	54%	8.1	1,010	1.3	5.0	na	no	no	yes	yes	no	1	0	0	0
Sodium	16	16	100%	40,939	63,700	na	na	na	yes	no	yes	no	no	0	0	0	1
Strontium	0	0	na	na	na	na	na	1,127,000	no	yes	no	no	yes	0	1	0	0
Thallium	0	16	0%	na	na	2.6	3.0	32	no	yes	no	yes	yes	0	0	0	1
Uranium	0	0	na	na	na	na	na	6,995	no	yes	no	no	yes	0	1	0	0
Vanadium	5	16	31%	3.4	6.0	0.6	1.5	835	no	yes	yes	yes	no	0	0	0	1
Zinc	444	558	80%	761	265,000	7.6	29	62,300	no	yes	yes	yes	yes	0	0	1	0
Cyanide, Dissolved*	120	158	76%	36	170	6.2	50	276,600	no	yes	yes	yes	no	0	0	0	1
Cyanide, Total	185	337	55%	82	695	4.2	11	276,600	no	yes	yes	yes	no				
<b>Total</b>														<b>6</b>	<b>3</b>	<b>2</b>	<b>20</b>

Surface water concentrations used in the COPC screen are based on total recoverable analysis.

\* Although the USGS reports "dissolved" cyanide, a review of this analytical method indicates that concentrations are likely to be representative of total.

a Essential nutrients are defined as: calcium, magnesium, potassium, and sodium.

**Appendix C.3**  
**Selection of Sediment COPCs for Aquatic Receptors**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

Parameter	Number of Detections	Number of Samples	Detection Frequency (DF)	Mean Detected Conc (mg/kg)	Maximum Detected Conc (mg/kg)	Mean Non- Detected Conc (mg/kg)	Maximum Non- Detected Conc (mg/kg)	Aquatic Benchmark (mg/kg)	Does cmpd have an TRV?	Is DF > 5%?	Is Mean DL < Benchmark?	Is Max Detect > Benchmark?	Qual Type 1	Qual Type 2	Quant COPC	Not a COPC
Aluminum	14	14	100%	6,443	10,300	na	na	14000	yes	yes	no	no	0	0	0	1
Antimony	5	14	36%	2.2	3.2	0.5	0.6	na	no	yes	yes	no	1	0	0	0
Arsenic	14	14	100%	605	1,400	na	na	9.8	yes	yes	no	yes	0	0	1	0
Barium	14	14	100%	183.7	440.0	na	na	na	no	yes	no	no	1	0	0	0
Beryllium	14	14	100%	1	1	na	na	na	no	yes	no	no	1	0	0	0
Boron	14	14	100%	11.8	41.7	na	na	na	no	yes	no	no	1	0	0	0
Cadmium	14	14	100%	1	2	na	na	1	yes	yes	no	yes	0	0	1	0
Calcium	14	14	100%	36,314.3	163,000.0	na	na	na	no	yes	no	no	1	0	0	0
Chromium	14	14	100%	13	30	na	na	43	yes	yes	no	no	0	0	0	1
Cobalt	14	14	100%	9.5	15.2	na	na	na	no	yes	no	no	1	0	0	0
Copper	14	14	100%	42	109	na	na	32	yes	yes	no	yes	0	0	1	0
Cyanide	3	14	21%	2	3	0	1	na	no	yes	yes	no	1	0	0	0
Iron	14	14	100%	37,334	59,500	na	na	190,000	yes	yes	no	no	0	0	0	1
Lead	14	14	100%	34	245	na	na	35.80	yes	yes	no	yes	0	0	1	0
Magnesium	14	14	100%	6,650	16,100	na	na	na	no	yes	no	no	1	0	0	0
Manganese	14	14	100%	743	1,130	na	na	630.00	yes	yes	no	yes	0	0	1	0
Mercury	12	14	86%	0	1	0	0	0.18	yes	yes	yes	yes	0	0	1	0
Molybdenum	13	14	93%	2	5	0	0	na	no	yes	yes	no	1	0	0	0
Nickel	14	14	100%	23	39	na	na	22.70	yes	yes	no	yes	0	0	1	0
Potassium	14	14	100%	1,755	2,830	na	na	na	no	yes	no	no	1	0	0	0
Selenium	14	14	100%	2	3	na	na	na	no	yes	no	no	1	0	0	0
Silver	4	14	29%	0	1	0	0	0.73	yes	yes	yes	no	0	0	0	1
Sodium	14	14	100%	180	445	na	na	na	no	yes	no	no	1	0	0	0
Thallium	0	14	0%	na	na	1	1	na	no	no	yes	no	1	0	0	0
Vanadium	14	14	100%	30	50	na	na	na	no	yes	no	no	1	0	0	0
Zinc	14	14	100%	93	216	na	na	121.00	yes	yes	no	yes	0	0	1	0

Total                      14                      0                      8                      3

**Appendix C.4**  
**Selection of Sediment COPCs for Wildlife Receptors**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

Parameter	Number of Detections	Number of Samples	Detection Frequency (DF)	Mean Detected Conc (mg/kg)	Maximum Detected Conc (mg/kg)	Mean Non- Detected Conc (mg/kg)	Maximum Non- Detected Conc (mg/kg)	Wildlife Benchmark (mg/kg)	Is cmpd essential nutrient? <sup>a</sup>	Does cmpd have an TRV?	Is DF > 5%?	Is Mean DL < Benchmark?	Is Max Detect > Benchmark?	Qual Type 1	Qual Type 2	Quant COPC	Not a COPC
Aluminum	14	14	100%	6,443	10,300	na	na	3.8	no	yes	yes	no	yes	0	0	1	0
Antimony	5	14	36%	2.2	3.2	0.5	0.6	0.2	no	yes	yes	no	yes	0	0	1	0
Arsenic	14	14	100%	605	1,400	na	na	0.3	no	yes	yes	no	yes	0	0	1	0
Barium	14	14	100%	183.7	440.0	na	na	17.2	no	yes	yes	no	yes	0	0	1	0
Beryllium	14	14	100%	1	1	na	na	2.4	no	yes	yes	no	no	0	0	0	1
Boron	14	14	100%	11.8	41.7	na	na	24.0	no	yes	yes	no	yes	0	0	1	0
Cadmium	14	14	100%	1	2	na	na	1.2	no	yes	yes	no	yes	0	0	1	0
Calcium	14	14	100%	36,314.3	163,000.0	na	na	na	no	no	yes	no	no	1	0	0	0
Chromium	14	14	100%	13	30	na	na	1	no	yes	yes	no	yes	0	0	1	0
Cobalt	14	14	100%	9.5	15.2	na	na	na	no	no	yes	no	no	1	0	0	0
Copper	14	14	100%	42	109	na	na	38.9	no	yes	yes	no	yes	0	0	1	0
Cyanide	3	14	21%	2	3	0	1	236.0	no	yes	yes	yes	no	0	0	0	1
Iron	14	14	100%	37,334	59,500	na	na	na	no	no	yes	no	no	1	0	0	0
Lead	14	14	100%	34	245	na	na	0.9	no	yes	yes	no	yes	0	0	1	0
Magnesium	14	14	100%	6,650	16,100	na	na	na	no	no	yes	no	no	1	0	0	0
Manganese	14	14	100%	743	1,130	na	na	322.0	no	yes	yes	no	yes	0	0	1	0
Mercury	12	14	86%	0	1	0	0	0.0	no	yes	yes	no	yes	0	0	1	0
Molybdenum	13	14	93%	2	5	0	0	0.5	no	yes	yes	yes	yes	0	0	1	0
Nickel	14	14	100%	23	39	na	na	64.1	no	yes	yes	no	no	0	0	0	1
Potassium	14	14	100%	1,755	2,830	na	na	na	no	no	yes	no	no	1	0	0	0
Selenium	14	14	100%	2	3	na	na	0.3	yes	yes	yes	no	yes	0	0	0	1
Silver	4	14	29%	0	1	0	0	na	no	no	yes	yes	no	1	0	0	0
Sodium	14	14	100%	180	445	na	na	na	no	no	yes	no	no	1	0	0	0
Thallium	0	14	0%	na	na	1	1	0.0	no	yes	no	no	yes	0	1	0	0
Vanadium	14	14	100%	30	50	na	na	0.7	no	yes	yes	no	yes	0	0	1	0
Zinc	14	14	100%	93	216	na	na	12.0	no	yes	yes	no	yes	0	0	1	0

<sup>a</sup> Essential nutrients are defined as: calcium, magnesium, potassium, and sodium (including dissolved state).

**Appendix C.5**  
**Selection of Soil COPCs for Wildlife Receptors**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

Parameter	Number of Detections	Number of Samples	Detection Frequency (DF)	Mean Detected Conc (mg/kg)	Maximum Detected Conc (mg/kg)	Mean Non- Detected Conc (mg/kg)	Maximum Non- Detected Conc (mg/kg)	Wildlife Benchmark (mg/kg)	Is cmpd essential nutrient? <sup>a</sup>	Does cmpd have an TRV?	Is DF > 5%?	Is Mean DL < Benchmark?	Is Max Detect > Benchmark?	Qual Type 1	Qual Type 2	Quant COPC	Not a COPC
Aluminum	38	38	100%	6,952	19,000	na	na	3.8	no	yes	yes	no	yes	0	0	1	0
Antimony	17	38	45%	12.0	92.1	2.8	4.3	0.2	no	yes	yes	no	yes	0	0	1	0
Arsenic	29	38	76%	1,939	8,600	0	0	0.3	no	yes	yes	yes	yes	0	0	1	0
Barium	38	38	100%	176.5	857.0	na	na	17.2	no	yes	yes	no	yes	0	0	1	0
Beryllium	32	38	84%	1	5	0	0	2.4	no	yes	yes	yes	yes	0	0	1	0
Boron	36	38	95%	8.0	15.4	1.50	1.50	24.0	no	yes	yes	yes	no	0	0	0	1
Cadmium	17	38	45%	1	2	1	2	1.2	no	yes	yes	yes	yes	0	0	1	0
Calcium	38	38	100%	28,513.2	130,000.0	na	na	na	no	no	yes	no	no	1	0	0	0
Chromium	38	38	100%	11	23	na	na	1	no	yes	yes	no	yes	0	0	1	0
Cobalt	38	38	100%	8.9	19.0	na	na	na	no	no	yes	no	no	1	0	0	0
Copper	38	38	100%	40	140	na	na	38.9	no	yes	yes	no	yes	0	0	1	0
Cyanide	2	10	20%	1	1	0	1	236.0	no	yes	yes	yes	no	0	0	0	1
Iron	38	38	100%	39,559	120,000	na	na	na	no	no	yes	no	no	1	0	0	0
Lead	38	38	100%	22	58	na	na	0.9	no	yes	yes	no	yes	0	0	1	0
Magnesium	38	38	100%	7,835	20,900	na	na	na	no	no	yes	no	no	1	0	0	0
Manganese	38	38	100%	853	2,800	na	na	322.0	no	yes	yes	no	yes	0	0	1	0
Mercury	28	38	74%	1	4	0	0	0.0	no	yes	yes	no	yes	0	0	1	0
Molybdenum	19	38	50%	2	7	0	1	0.5	no	yes	yes	yes	yes	0	0	1	0
Nickel	38	38	100%	15	42	na	na	64.1	no	yes	yes	no	no	0	0	0	1
Potassium	38	38	100%	1,737	4,200	na	na	na	no	no	yes	no	no	1	0	0	0
Selenium	22	38	58%	3	10	1	2	0.3	yes	yes	yes	no	yes	0	0	0	1
Silver	27	38	71%	1	7	0	0	na	no	no	yes	yes	no	1	0	0	0
Sodium	22	38	58%	71	220	15	38	na	no	no	yes	yes	no	1	0	0	0
Thallium	19	38	50%	1	5	0	0	0.0	no	yes	yes	no	yes	0	0	1	0
Vanadium	38	38	100%	25	124	na	na	0.7	no	yes	yes	no	yes	0	0	1	0
Zinc	38	38	100%	69	309	na	na	12.0	no	yes	yes	no	yes	0	0	1	0

<sup>a</sup> Essential nutrients are defined as: calcium, magnesium, potassium, and sodium (including dissolved state).

**Total**      **7**      **0**      **15**      **4**

**Appendix C.6**  
**Selection of Soil COPCs for Terrestrial Receptors**

*Ecological Risk Assessment*  
*Whitewood Creek, Lead, South Dakota*

Parameter	Number of Detections	Number of Samples	Detection Frequency (DF)	Mean Detected Conc (mg/kg)	Maximum Detected Conc (mg/kg)	Mean Non- Detected Conc (mg/kg)	Maximum Non- Detected Conc (mg/kg)	Terrestrial Benchmark (mg/kg)	Is cmpd essential nutrient? <sup>a</sup>	Does cmpd have an TRV?	Is DF > 5%?	Is Mean DL < Benchmark?	Is Max Detect > Benchmark?	Qual Type 1	Qual Type 2	Quant COPC	Not a COPC
Aluminum	38	38	100%	6,952	19,000	na	na	50.0	no	yes	yes	no	yes	0	0	1	0
Antimony	17	38	45%	12.0	92.1	2.8	4.3	5.0	no	yes	yes	yes	yes	0	0	1	0
Arsenic	29	38	76%	1,939	8,600	0	0	10.0	no	yes	yes	yes	yes	0	0	1	0
Barium	38	38	100%	176.5	857.0	na	na	500.0	no	yes	yes	no	yes	0	0	1	0
Beryllium	32	38	84%	1	5	0	0	10.0	no	yes	yes	yes	no	0	0	0	1
Boron	36	38	95%	8.0	15.4	1.50	1.50	0.5	no	yes	yes	no	yes	0	0	1	0
Cadmium	17	38	45%	1	2	1	2	3.0	no	yes	yes	yes	no	0	0	0	1
Calcium	38	38	100%	28,513.2	130,000.0	na	na	NA	no	no	yes	no	no	1	0	0	0
Chromium	38	38	100%	11	23	na	na	0	no	yes	yes	no	yes	0	0	1	0
Cobalt	38	38	100%	8.9	19.0	na	na	20.00	no	yes	yes	no	no	0	0	0	1
Copper	38	38	100%	40	140	na	na	40.0	no	yes	yes	no	yes	0	0	1	0
Cyanide	2	10	20%	1	1	0	1	NA	no	no	yes	yes	no	1	0	0	0
Iron	38	38	100%	39,559	120,000	na	na	200.0	no	yes	yes	no	yes	0	0	1	0
Lead	38	38	100%	22	58	na	na	50.0	no	yes	yes	no	yes	0	0	1	0
Magnesium	38	38	100%	7,835	20,900	na	na	NA	no	no	yes	no	no	1	0	0	0
Manganese	38	38	100%	853	2,800	na	na	100.0	no	yes	yes	no	yes	0	0	1	0
Mercury	28	38	74%	1	4	0	0	0.1	no	yes	yes	yes	yes	0	0	1	0
Molybdenum	19	38	50%	2	7	0	1	2.0	no	yes	yes	yes	yes	0	0	1	0
Nickel	38	38	100%	15	42	na	na	30.0	no	yes	yes	no	yes	0	0	1	0
Potassium	38	38	100%	1,737	4,200	na	na	NA	no	no	yes	no	no	1	0	0	0
Selenium	22	38	58%	3	10	1	2	1.0	yes	yes	yes	no	yes	0	0	0	1
Silver	27	38	71%	1	7	0	0	2.0	no	yes	yes	yes	yes	0	0	1	0
Sodium	22	38	58%	71	220	15	38	NA	no	no	yes	yes	no	1	0	0	0
Thallium	19	38	50%	1	5	0	0	1.0	no	yes	yes	yes	yes	0	0	1	0
Vanadium	38	38	100%	25	124	na	na	2.0	no	yes	yes	no	yes	0	0	1	0
Zinc	38	38	100%	69	309	na	na	50.0	no	yes	yes	no	yes	0	0	1	0

<sup>a</sup> Essential nutrients are defined as: calcium, magnesium, potassium, and sodium (including dissolved state).

**Total**      **5**      **0**      **17**      **4**

## **APPENDIX D**

### **ANALYTICAL RESULTS**

*Electronic Database Provided Upon Request*

## **APPENDIX E**

### **DETAILED RISK CALCULATIONS FOR AQUATIC RECEPTORS FROM DIRECT CONTACT WITH SURFACE WATER - BASED ON NATIONAL AMBIENT WATER QUALITY CRITERIA (AWQC)**

**APPENDIX E**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Aq SW COPCs	Adj Conc (mg/L)	Hardness (mg/L)	HQacute	HQchronic
SDDENR electronic	460122	WWC	Site	5/27/1997	955	Water Quality Monitoring	Dissolved	Copper	0.005	301	1E-01	3E-01
USGS electronic	6436198	WWC	Site	8/20/1996	12:15:00 PM	Gaging Station	DISSOLVED	Selenium	0.002	670	1E-01	4E-01
USGS electronic	6436180	WWC	Site	2/12/1992	10:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.003	540	2E-01	7E-01
USGS electronic	6436180	WWC	Site	4/14/1993	9:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	260	1E-01	4E-01
USGS electronic	6436198	WWC	Site	8/18/1994	9:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	640	1E-01	4E-01
USGS electronic	6436180	WWC	Site	11/8/1990	10:30:00 AM	Gaging Station	DISSOLVED	Copper	0.005	500	1E-01	3E-01
USGS electronic	6436198	WWC	Site	5/6/1993	3:50:00 PM	Gaging Station	DISSOLVED	Selenium	0.001	290	6E-02	2E-01
USGS electronic	6436180	WWC	Site	6/9/1998	9:05:00 AM	Gaging Station	DISSOLVED	Copper	0.00427	380	9E-02	3E-01
USGS electronic	6436198	WWC	Site	5/8/1997	9:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.00114	230	6E-02	2E-01
SDDENR electronic	460122	WWC	Site	6/25/1997	845	Water Quality Monitoring	Dissolved	Copper	0.005	447	1E-01	3E-01
SDDENR electronic	460682	WWC	Site	9/23/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	613	1E-01	3E-01
SDDENR electronic	460682	WWC	Site	1/14/1998	910	Water Quality Monitoring	Dissolved	Copper	0.005	917	1E-01	3E-01
EPA (1999) - Aquatic	WWC-09	WWC	Site	9/1/1999	--	Field	Dissolved	Copper	0.003	704	6E-02	2E-01
USGS electronic	6436180	WWC	Site	12/13/1990	9:45:00 AM	Gaging Station	DISSOLVED	Copper	0.01	500	2E-01	6E-01
SDDENR electronic	460122	WWC	Site	7/21/1997	1310	Water Quality Monitoring	Dissolved	Copper	0.007	480	1E-01	4E-01
USGS electronic	6436180	WWC	Site	10/23/1996	9:10:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	490	1E-01	4E-01
USGS electronic	6436198	WWC	Site	1/23/1991	8:45:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	680	7E-03	6E-02
USGS electronic	6436180	WWC	Site	12/17/1991	1:45:00 PM	Gaging Station	DISSOLVED	Selenium	0.005	520	3E-01	1E+00
USGS electronic	6436180	WWC	Site	7/11/1991	9:45:00 AM	Gaging Station	DISSOLVED	Selenium	0.003	350	2E-01	7E-01
USGS electronic	6436198	WWC	Site	9/1/1994	10:15:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	570	1E-01	4E-01
USGS electronic	6436198	WWC	Site	6/26/1996	8:10:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	640	1E-01	4E-01
USGS electronic	6436180	WWC	Site	10/13/1992	11:15:00 AM	Gaging Station	DISSOLVED	Selenium	0.005	540	3E-01	1E+00
USGS electronic	6436180	WWC	Site	11/27/1991	9:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.005	460	3E-01	1E+00
SDDENR electronic	460682	WWC	Site	3/24/1998	1450	Water Quality Monitoring	Dissolved	Copper	0.005	592	1E-01	3E-01
USGS electronic	6436198	WWC	Site	12/9/1992	12:30:00 PM	Gaging Station	DISSOLVED	Selenium	0.003	640	2E-01	7E-01
USGS electronic	6436198	WWC	Site	12/21/1994	9:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	630	1E-01	4E-01
USGS electronic	6436198	WWC	Site	8/12/1992	8:45:00 AM	Gaging Station	DISSOLVED	Selenium	0.006	550	3E-01	1E+00
USGS electronic	6436198	WWC	Site	10/24/1996	9:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	670	1E-01	4E-01
USGS electronic	6436198	WWC	Site	8/26/1997	12:30:00 PM	Gaging Station	DISSOLVED	Selenium	0.0017	560	1E-01	4E-01
USGS electronic	6436180	WWC	Site	8/11/1992	8:45:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	580	1E-01	4E-01
USGS electronic	6436198	WWC	Site	2/19/1993	10:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.003	690	2E-01	7E-01
SDDENR electronic	460682	WWC	Site	2/18/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	630	1E-01	3E-01
SDDENR electronic	460122	WWC	Site	4/21/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	240	2E-01	3E-01
USGS electronic	6436180	WWC	Site	3/6/1991	12:30:00 PM	Gaging Station	DISSOLVED	Copper	0.01	520	2E-01	6E-01
SDDENR electronic	460122	WWC	Site	3/24/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	486	1E-01	3E-01
SDDENR electronic	460122	WWC	Site	12/16/1997	1040	Water Quality Monitoring	Dissolved	Copper	0.005	580	1E-01	3E-01
SDDENR electronic	460122	WWC	Site	1/13/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	673	1E-01	3E-01
USGS electronic	6436180	WWC	Site	9/12/1991	9:45:00 AM	Gaging Station	DISSOLVED	Copper	0.01	580	2E-01	6E-01
SDDENR electronic	460682	WWC	Site	4/20/1998	1220	Water Quality Monitoring	Dissolved	Copper	0.005	382	1E-01	3E-01
SDDENR electronic	460682	WWC	Site	5/12/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	434	1E-01	3E-01
USGS electronic	6436180	WWC	Site	5/9/1991	8:30:00 AM	Gaging Station	DISSOLVED	Copper	0.005	330	1E-01	3E-01
SDDENR electronic	460123	WWC	Site	12/16/1997	1105	Water Quality Monitoring	Dissolved	Copper	0.005	251	2E-01	3E-01
SDDENR electronic	460684	WWC	Site	11/24/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	451	1E-01	3E-01
USGS electronic	6436180	WWC	Site	6/21/1990	6:00:00 PM	Gaging Station	DISSOLVED	Copper	0.01	400	2E-01	6E-01
SDDENR electronic	460122	WWC	Site	2/18/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	538	1E-01	3E-01
USGS electronic	6436180	WWC	Site	5/24/1995	8:30:00 AM	Gaging Station	DISSOLVED	Copper	0.01	270	3E-01	6E-01
USGS electronic	6436198	WWC	Site	5/5/1999	10:45:00 AM	Gaging Station	DISSOLVED	Selenium	0.00208	na	1E-01	5E-01
SDDENR electronic	460682	WWC	Site	10/28/1997	1435	Water Quality Monitoring	Dissolved	Copper	0.005	779	1E-01	3E-01
USGS electronic	6436180	WWC	Site	5/8/1995	6:45:00 PM	Gaging Station	DISSOLVED	Copper	0.01	110	7E-01	1E+00
SDDENR electronic	460682	WWC	Site	8/18/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	559	1E-01	3E-01
SDDENR electronic	460682	WWC	Site	6/25/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	650	1E-01	3E-01
USGS electronic	6436180	WWC	Site	5/24/1994	11:10:00 AM	Gaging Station	DISSOLVED	Copper	0.005	290	1E-01	3E-01
SDDENR electronic	460682	WWC	Site	5/27/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	526	1E-01	3E-01
SDDENR electronic	460122	WWC	Site	10/27/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	423	1E-01	3E-01
SDDENR electronic	460682	WWC	Site	11/24/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	675	1E-01	3E-01
SDDENR electronic	460122	WWC	Site	11/24/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	517	1E-01	3E-01
SDDENR electronic	460122	WWC	Site	8/18/1997	950	Water Quality Monitoring	Dissolved	Copper	0.005	449	1E-01	3E-01
USGS electronic	6436180	WWC	Site	8/26/1997	8:30:00 AM	Gaging Station	DISSOLVED	Copper	0.005	410	1E-01	3E-01
SDDENR electronic	460122	WWC	Site	9/23/1997	955	Water Quality Monitoring	Dissolved	Copper	0.005	505	1E-01	3E-01
SDDENR electronic	460682	WWC	Site	12/16/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	555	1E-01	3E-01
USGS electronic	6436180	WWC	Site	4/21/1994	7:45:00 AM	Gaging Station	DISSOLVED	Copper	0.01	130	6E-01	9E-01
USGS electronic	6436198	WWC	Site	9/9/1993	10:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.001	630	6E-02	2E-01
USGS electronic	6436180	WWC	Site	6/25/1996	11:05:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	340	1E-01	4E-01
USGS electronic	6436180	WWC	Site	8/20/1996	9:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.004	480	2E-01	9E-01
EPA (1999) - Aquatic	WWC-05	WWC	Site	9/1/1999	--	Field	Dissolved	Selenium	0.0066	496	4E-01	1E+00

**APPENDIX E**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Aq SW COPCs	Adj Conc (mg/L)	Hardness (mg/L)	HQacute	HQchronic
USGS electronic	6436198	WWC	Site	2/15/1994	9:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	550	1E-01	4E-01
USGS electronic	6436180	WWC	Site	9/2/1998	9:40:00 AM	Gaging Station	DISSOLVED	Selenium	0.00182	na	1E-01	4E-01
USGS electronic	6436180	WWC	Site	4/28/1992	12:30:00 PM	Gaging Station	DISSOLVED	Selenium	0.002	270	1E-01	4E-01
USGS electronic	6436180	WWC	Site	6/3/1999	10:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.0005	na	3E-02	1E-01
USGS electronic	6436198	WWC	Site	3/16/1994	9:45:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	380	1E-01	4E-01
USGS electronic	6436198	WWC	Site	12/23/1997	9:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.0026	750	1E-01	6E-01
USGS electronic	6436198	WWC	Site	1/8/1997	10:20:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	590	1E-01	4E-01
USGS electronic	6436198	WWC	Site	3/10/1992	9:15:00 AM	Gaging Station	DISSOLVED	Selenium	0.001	530	6E-02	2E-01
USGS electronic	6436180	WWC	Site	2/18/1993	10:45:00 AM	Gaging Station	DISSOLVED	Selenium	0.003	580	2E-01	7E-01
USGS electronic	6436198	WWC	Site	1/9/1996	11:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	710	1E-01	4E-01
USGS electronic	6436180	WWC	Site	5/25/1996	10:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.001	210	6E-02	2E-01
USGS electronic	6436198	WWC	Site	4/29/1992	9:15:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	340	1E-01	4E-01
USGS electronic	6436180	WWC	Site	10/22/1991	7:45:00 AM	Gaging Station	DISSOLVED	Selenium	0.005	510	3E-01	1E+00
USGS electronic	6436198	WWC	Site	7/20/1994	9:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	530	1E-01	4E-01
USGS electronic	6436180	WWC	Site	3/17/1993	9:45:00 AM	Gaging Station	DISSOLVED	Selenium	0.003	530	2E-01	7E-01
USGS electronic	6436180	WWC	Site	9/13/2000	10:00:00 AM	Water Quality Monitoring	Dissolved	Selenium	0.0022	na	1E-01	5E-01
USGS electronic	6436198	WWC	Site	4/10/1991	8:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.003	490	2E-01	7E-01
EPA (1999) - Aquatic	BFR-11	BFRd	Site	9/1/1999	--	Field	Dissolved	Selenium	0.006	661	3E-01	1E+00
USGS electronic	6436198	WWC	Site	6/5/1991	12:00:00 PM	Gaging Station	DISSOLVED	Selenium	0.001	320	6E-02	2E-01
USGS electronic	6436198	WWC	Site	12/17/1991	9:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.003	680	2E-01	7E-01
EPA (1999) - Aquatic	WWC-06	WWC	Site	9/1/1999	--	Field	Dissolved	Selenium	0.009	537	5E-01	2E+00
USGS electronic	6436198	WWC	Site	4/29/1998	10:10:00 AM	Gaging Station	DISSOLVED	Selenium	0.0015	340	8E-02	3E-01
USGS electronic	6436198	WWC	Site	1/15/1992	1:30:00 PM	Gaging Station	DISSOLVED	Selenium	0.001	780	6E-02	2E-01
USGS electronic	6436180	WWC	Site	9/13/1999	8:15:00 AM	Gaging Station	DISSOLVED	Selenium	0.00115	na	6E-02	2E-01
USGS electronic	6436198	WWC	Site	1/7/1993	11:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	510	1E-01	4E-01
EPA (1999) - Aquatic	WWC-04	WWC	Site	9/1/1999	--	Field	Dissolved	Selenium	0.0057	434	3E-01	1E+00
USGS electronic	6436198	WWC	Site	8/30/1995	12:15:00 PM	Gaging Station	DISSOLVED	Selenium	0.001	740	6E-02	2E-01
USGS electronic	6436198	WWC	Site	12/28/1993	9:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	730	1E-01	4E-01
USGS electronic	6436198	WWC	Site	1/23/1991	8:45:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	680	1E-01	4E-01
USGS electronic	6436180	WWC	Site	5/8/1996	8:40:00 AM	Gaging Station	DISSOLVED	Selenium	0.0005	190	3E-02	1E-01
USGS electronic	6436180	WWC	Site	9/12/1991	9:45:00 AM	Gaging Station	DISSOLVED	Selenium	0.005	580	3E-01	1E+00
USGS electronic	6436198	WWC	Site	10/14/1992	8:45:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	570	1E-01	4E-01
USGS electronic	6436180	WWC	Site	3/11/1992	11:15:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	420	1E-01	4E-01
USGS electronic	6436198	WWC	Site	6/3/1999	2:00:00 PM	Gaging Station	DISSOLVED	Selenium	0.0005	na	3E-02	1E-01
USGS electronic	6436180	WWC	Site	5/6/1993	1:15:00 PM	Gaging Station	DISSOLVED	Selenium	0.001	170	6E-02	2E-01
USGS electronic	6436180	WWC	Site	1/6/1993	11:45:00 AM	Gaging Station	DISSOLVED	Selenium	0.005	320	3E-01	1E+00
USGS electronic	6436198	WWC	Site	5/9/1995	8:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.001	280	6E-02	2E-01
USGS electronic	6436198	WWC	Site	8/14/1991	8:45:00 AM	Gaging Station	DISSOLVED	Selenium	0.001	590	6E-02	2E-01
USGS electronic	6436198	WWC	Site	9/11/1991	8:15:00 AM	Gaging Station	DISSOLVED	Selenium	0.0005	630	3E-02	1E-01
USGS electronic	6436198	WWC	Site	3/18/1993	9:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	650	1E-01	4E-01
USGS electronic	6436180	WWC	Site	9/2/1992	11:45:00 AM	Gaging Station	DISSOLVED	Selenium	0.006	510	3E-01	1E+00
USGS electronic	6436198	WWC	Site	9/13/1999	12:25:00 PM	Gaging Station	DISSOLVED	Selenium	0.00142	na	8E-02	3E-01
USGS electronic	6436198	WWC	Site	5/10/1993	3:30:00 PM	Gaging Station	DISSOLVED	Selenium	0.001	250	6E-02	2E-01
USGS electronic	6436180	WWC	Site	12/9/1992	9:20:00 AM	Gaging Station	DISSOLVED	Selenium	0.006	560	3E-01	1E+00
USGS electronic	6436198	WWC	Site	11/17/1992	11:15:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	590	1E-01	4E-01
SDDENR electronic	460123	WWC	Site	3/24/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	408	1E-01	3E-01
USGS electronic	6436180	WWC	Site	1/16/1990	2:30:00 PM	Gaging Station	DISSOLVED	Selenium	0.003	470	2E-01	7E-01
USGS electronic	6436198	WWC	Site	2/11/1992	11:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.003	660	2E-01	7E-01
USGS electronic	6436180	WWC	Site	12/29/1999	9:20 AM	Water Quality Monitoring	Dissolved	Selenium	0.0023	na	1E-01	5E-01
USGS electronic	6436180	WWC	Site	4/28/1998	10:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.0012	230	7E-02	3E-01
USGS electronic	6436198	WWC	Site	12/16/1998	2:15:00 PM	Gaging Station	DISSOLVED	Selenium	0.00285	na	2E-01	6E-01
USGS electronic	6436180	WWC	Site	11/16/1992	10:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.004	560	2E-01	9E-01
USGS electronic	6436180	WWC	Site	5/10/1993	10:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.001	160	6E-02	2E-01
USGS electronic	6436198	WWC	Site	3/6/1991	8:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	450	1E-01	4E-01
EPA (1999) - Aquatic	WWC-02	WWC	Site	9/1/1999	--	Field	Dissolved	Selenium	0.0056	233	3E-01	1E+00
USGS electronic	6436180	WWC	Site	2/12/1990	1:00:00 PM	Gaging Station	DISSOLVED	Selenium	0.002	450	1E-01	4E-01
USGS electronic	6436198	WWC	Site	9/3/1992	7:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	590	1E-01	4E-01
USGS electronic	6436180	WWC	Site	6/9/1998	9:05:00 AM	Gaging Station	DISSOLVED	Selenium	0.00183	380	1E-01	4E-01
USGS electronic	6436198	WWC	Site	4/15/1993	9:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	380	1E-01	4E-01
USGS electronic	6436180	WWC	Site	1/7/1997	10:15:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	390	1E-01	4E-01
EPA (1999) - Aquatic	SPC-R-12	OTHER	Ref	9/1/1999	--	Field	Dissolved	Selenium	0.0074	292	4E-01	2E+00
USGS electronic	6436198	WWC	Site	11/7/1990	12:15:00 PM	Gaging Station	DISSOLVED	Copper	0.005	580	1E-01	3E-01
SDDENR electronic	460684	WWC	Site	12/16/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	218	2E-01	3E-01
EPA (1999) - Aquatic	WWC-08	WWC	Site	9/1/1999	--	Duplicate	Dissolved	Copper	0.0025	606	5E-02	1E-01
USGS electronic	6436198	WWC	Site	5/24/1995	12:00:00 PM	Gaging Station	DISSOLVED	Copper	0.005	530	1E-01	3E-01

**APPENDIX E**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Aq SW COPCs	Adj Conc (mg/L)	Hardness (mg/L)	HQacute	HQchronic
USGS electronic	6436198	WWC	Site	10/9/1990	11:30:00 AM	Gaging Station	DISSOLVED	Copper	0.005	540	1E-01	3E-01
EPA (1999) - Aquatic	WWC-08	WWC	Site	9/1/1999	--	Field	Dissolved	Copper	0.0026	597	5E-02	2E-01
EPA (1999) - Aquatic	WWC-07	WWC	Site	9/1/1999	--	Field	Dissolved	Copper	0.0025	560	5E-02	1E-01
USGS electronic	6436180	WWC	Site	2/12/1992	10:30:00 AM	Gaging Station	DISSOLVED	Copper	0.005	540	1E-01	3E-01
USGS electronic	6436198	WWC	Site	10/21/1991	10:45:00 AM	Gaging Station	DISSOLVED	Copper	0.005	620	1E-01	3E-01
USGS electronic	6436180	WWC	Site	3/11/1992	11:15:00 AM	Gaging Station	DISSOLVED	Copper	0.01	420	2E-01	6E-01
USGS electronic	6436198	WWC	Site	12/21/1994	9:00:00 AM	Gaging Station	DISSOLVED	Copper	0.005	630	1E-01	3E-01
USGS electronic	6436198	WWC	Site	12/12/1990	11:30:00 AM	Gaging Station	DISSOLVED	Copper	0.005	590	1E-01	3E-01
USGS electronic	6436198	WWC	Site	9/1/1994	10:15:00 AM	Gaging Station	DISSOLVED	Copper	0.005	570	1E-01	3E-01
USGS electronic	6436198	WWC	Site	1/23/1991	8:45:00 AM	Gaging Station	DISSOLVED	Copper	0.005	680	1E-01	3E-01
USGS electronic	6436198	WWC	Site	5/9/1995	8:30:00 AM	Gaging Station	DISSOLVED	Copper	0.005	280	1E-01	3E-01
USGS electronic	6436180	WWC	Site	5/25/1996	10:00:00 AM	Gaging Station	DISSOLVED	Copper	0.005	210	2E-01	3E-01
USGS electronic	6436198	WWC	Site	6/5/1991	12:00:00 PM	Gaging Station	DISSOLVED	Copper	0.005	320	1E-01	3E-01
USGS electronic	6436198	WWC	Site	7/10/1991	1:00:00 PM	Gaging Station	DISSOLVED	Copper	0.005	480	1E-01	3E-01
USGS electronic	6436198	WWC	Site	4/10/1991	8:30:00 AM	Gaging Station	DISSOLVED	Copper	0.005	490	1E-01	3E-01
USGS electronic	6436198	WWC	Site	4/21/1994	1:00:00 PM	Gaging Station	DISSOLVED	Copper	0.005	180	2E-01	3E-01
USGS electronic	6436198	WWC	Site	8/30/1995	12:15:00 PM	Gaging Station	DISSOLVED	Copper	0.005	740	1E-01	3E-01
USGS electronic	6436198	WWC	Site	3/16/1994	9:45:00 AM	Gaging Station	DISSOLVED	Copper	0.005	380	1E-01	3E-01
USGS electronic	6436180	WWC	Site	4/8/1992	2:15:00 PM	Gaging Station	DISSOLVED	Copper	0.03	450	6E-01	2E+00
USGS electronic	6436198	WWC	Site	8/14/1991	8:45:00 AM	Gaging Station	DISSOLVED	Copper	0.005	590	1E-01	3E-01
USGS electronic	6436198	WWC	Site	2/15/1994	9:00:00 AM	Gaging Station	DISSOLVED	Copper	0.005	550	1E-01	3E-01
USGS electronic	6436198	WWC	Site	9/11/1991	8:15:00 AM	Gaging Station	DISSOLVED	Copper	0.005	630	1E-01	3E-01
USGS electronic	6436180	WWC	Site	6/11/1992	10:45:00 AM	Gaging Station	DISSOLVED	Copper	0.02	400	4E-01	1E+00
USGS electronic	6436180	WWC	Site	4/28/1992	12:30:00 PM	Gaging Station	DISSOLVED	Copper	0.01	270	3E-01	6E-01
USGS electronic	6436180	WWC	Site	7/14/1993	9:15:00 AM	Gaging Station	DISSOLVED	Copper	0.01	370	2E-01	6E-01
USGS electronic	6436180	WWC	Site	5/6/1993	1:15:00 PM	Gaging Station	DISSOLVED	Copper	0.01	170	5E-01	7E-01
USGS electronic	6436198	WWC	Site	3/6/1991	8:30:00 AM	Gaging Station	DISSOLVED	Copper	0.02	450	4E-01	1E+00
USGS electronic	6436180	WWC	Site	11/16/1992	10:30:00 AM	Gaging Station	DISSOLVED	Copper	0.005	560	1E-01	3E-01
USGS electronic	6436198	WWC	Site	2/19/1993	10:00:00 AM	Gaging Station	DISSOLVED	Copper	0.005	690	1E-01	3E-01
USGS electronic	6436198	WWC	Site	11/17/1992	11:15:00 AM	Gaging Station	DISSOLVED	Copper	0.005	590	1E-01	3E-01
USGS electronic	6436180	WWC	Site	10/13/1992	11:15:00 AM	Gaging Station	DISSOLVED	Copper	0.005	540	1E-01	3E-01
USGS electronic	6436198	WWC	Site	12/9/1992	12:30:00 PM	Gaging Station	DISSOLVED	Copper	0.005	640	1E-01	3E-01
USGS electronic	6436180	WWC	Site	6/15/1993	9:30:00 AM	Gaging Station	DISSOLVED	Copper	0.005	260	2E-01	3E-01
USGS electronic	6436198	WWC	Site	7/15/1993	9:30:00 AM	Gaging Station	DISSOLVED	Copper	0.005	500	1E-01	3E-01
EPA (1999) - Aquatic	SPC-R-12	OTHER	Ref	9/1/1999	--	Field	Dissolved	Copper	0.001	292	3E-02	6E-02
USGS electronic	6436198	WWC	Site	9/9/1993	10:30:00 AM	Gaging Station	DISSOLVED	Copper	0.005	630	1E-01	3E-01
USGS electronic	6436198	WWC	Site	11/26/1991	9:00:00 AM	Gaging Station	DISSOLVED	Copper	0.005	600	1E-01	3E-01
EPA (1999) - Aquatic	WWC-05	WWC	Site	9/1/1999	--	Field	Dissolved	Copper	0.0043	496	9E-02	3E-01
USGS electronic	6436198	WWC	Site	8/19/1993	10:00:00 AM	Gaging Station	DISSOLVED	Copper	0.005	630	1E-01	3E-01
USGS electronic	6436198	WWC	Site	12/17/1991	9:00:00 AM	Gaging Station	DISSOLVED	Copper	0.005	680	1E-01	3E-01
USGS electronic	6436180	WWC	Site	3/17/1993	9:45:00 AM	Gaging Station	DISSOLVED	Copper	0.01	530	2E-01	6E-01
USGS electronic	6436180	WWC	Site	1/23/1991	2:30:00 PM	Gaging Station	DISSOLVED	Copper	0.01	460	2E-01	6E-01
USGS electronic	6436180	WWC	Site	12/9/1992	9:20:00 AM	Gaging Station	DISSOLVED	Copper	0.005	560	1E-01	3E-01
USGS electronic	6436198	WWC	Site	5/8/1991	10:45:00 AM	Gaging Station	DISSOLVED	Copper	0.005	430	1E-01	3E-01
USGS electronic	6436180	WWC	Site	10/23/1996	9:10:00 AM	Gaging Station	DISSOLVED	Copper	0.005	490	1E-01	3E-01
USGS electronic	6436198	WWC	Site	3/18/1993	9:30:00 AM	Gaging Station	DISSOLVED	Copper	0.005	650	1E-01	3E-01
USGS electronic	6436198	WWC	Site	5/6/1993	3:50:00 PM	Gaging Station	DISSOLVED	Copper	0.005	290	1E-01	3E-01
USGS electronic	6436198	WWC	Site	6/12/1992	9:15:00 AM	Gaging Station	DISSOLVED	Copper	0.005	460	1E-01	3E-01
USGS electronic	6436198	WWC	Site	4/15/1993	9:00:00 AM	Gaging Station	DISSOLVED	Copper	0.005	380	1E-01	3E-01
EPA (1999) - Aquatic	WWC-02	WWC	Site	9/1/1999	--	Field	Dissolved	Copper	0.0016	233	5E-02	9E-02
EPA (1999) - Aquatic	WWC-03	WWC	Site	9/1/1999	--	Field	Dissolved	Copper	0.0042	499	8E-02	2E-01
USGS electronic	6436198	WWC	Site	10/14/1992	8:45:00 AM	Gaging Station	DISSOLVED	Copper	0.005	570	1E-01	3E-01
USGS electronic	6436180	WWC	Site	9/2/1992	11:45:00 AM	Gaging Station	DISSOLVED	Copper	0.01	510	2E-01	6E-01
USGS electronic	6436180	WWC	Site	6/25/1996	11:05:00 AM	Gaging Station	DISSOLVED	Copper	0.005	340	1E-01	3E-01
USGS electronic	6436198	WWC	Site	12/28/1993	9:30:00 AM	Gaging Station	DISSOLVED	Copper	0.005	730	1E-01	3E-01
USGS electronic	6436198	WWC	Site	9/3/1992	7:00:00 AM	Gaging Station	DISSOLVED	Copper	0.005	590	1E-01	3E-01
USGS electronic	6436198	WWC	Site	5/10/1993	3:30:00 PM	Gaging Station	DISSOLVED	Copper	0.005	250	2E-01	3E-01
USGS electronic	6436198	WWC	Site	8/18/1994	9:00:00 AM	Gaging Station	DISSOLVED	Copper	0.005	640	1E-01	3E-01
USGS electronic	6436198	WWC	Site	8/12/1992	8:45:00 AM	Gaging Station	DISSOLVED	Copper	0.005	550	1E-01	3E-01
SDDENR electronic	460684	WWC	Site	10/28/1997	1100	Water Quality Monitoring	Dissolved	Copper	0.005	547	1E-01	3E-01
SDDENR electronic	460684	WWC	Site	5/27/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	291	1E-01	3E-01
SDDENR electronic	460123	WWC	Site	11/24/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	490	1E-01	3E-01
USGS electronic	6436180	WWC	Site	9/1/1994	8:00:00 AM	Gaging Station	DISSOLVED	Copper	0.005	460	1E-01	3E-01
SDDENR electronic	460123	WWC	Site	5/12/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	295	1E-01	3E-01
USGS electronic	6436180	WWC	Site	8/15/1990	9:00:00 AM	Gaging Station	DISSOLVED	Copper	0.01	440	2E-01	6E-01

**APPENDIX E**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Aq SW COPCs	Adj Conc (mg/L)	Hardness (mg/L)	HQacute	HQchronic
SDDENR electronic	460684	WWC	Site	9/23/1997	1100	Water Quality Monitoring	Dissolved	Copper	0.005	431	1E-01	3E-01
USGS electronic	6436180	WWC	Site	8/30/1995	8:01:00 AM	Gaging Station	DISSOLVED	Copper	0.005	410	1E-01	3E-01
USGS electronic	6436180	WWC	Site	5/31/1990	9:30:00 AM	Gaging Station	DISSOLVED	Copper	0.005	300	1E-01	3E-01
USGS electronic	6436180	WWC	Site	8/15/1991	8:15:00 AM	Gaging Station	DISSOLVED	Copper	0.01	510	2E-01	6E-01
USGS electronic	6436180	WWC	Site	7/19/1994	9:00:00 AM	Gaging Station	DISSOLVED	Copper	0.01	450	2E-01	6E-01
USGS electronic	6436198	WWC	Site	5/25/1994	10:20:00 AM	Gaging Station	DISSOLVED	Copper	0.005	400	1E-01	3E-01
SDDENR electronic	460684	WWC	Site	8/18/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	389	1E-01	3E-01
USGS electronic	6436180	WWC	Site	9/7/1994	9:00:00 AM	Gaging Station	DISSOLVED	Copper	0.005	510	1E-01	3E-01
USGS electronic	6436180	WWC	Site	7/14/1992	11:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.004	440	2E-01	9E-01
USGS electronic	6436180	WWC	Site	2/12/1990	1:00:00 PM	Gaging Station	DISSOLVED	Copper	0.01	450	2E-01	6E-01
SDDENR electronic	460123	WWC	Site	4/21/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	247	2E-01	3E-01
SDDENR electronic	460684	WWC	Site	2/18/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	393	1E-01	3E-01
SDDENR electronic	460684	WWC	Site	3/24/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	366	1E-01	3E-01
SDDENR electronic	460684	WWC	Site	4/20/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	270	1E-01	3E-01
USGS electronic	6436180	WWC	Site	4/28/1998	10:30:00 AM	Gaging Station	DISSOLVED	Copper	0.001395	230	5E-02	8E-02
SDDENR electronic	460684	WWC	Site	5/12/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	281	1E-01	3E-01
USGS electronic	6436180	WWC	Site	3/29/1990	12:30:00 PM	Gaging Station	DISSOLVED	Copper	0.02	380	4E-01	1E+00
SDDENR electronic	460684	WWC	Site	1/14/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	606	1E-01	3E-01
SDDENR electronic	460684	WWC	Site	6/25/1997	1135	Water Quality Monitoring	Dissolved	Copper	0.005	408	1E-01	3E-01
USGS electronic	6436180	WWC	Site	6/11/1991	8:30:00 AM	Gaging Station	DISSOLVED	Copper	0.01	240	3E-01	6E-01
USGS electronic	6436180	WWC	Site	5/7/1997	10:15:00 AM	Gaging Station	DISSOLVED	Copper	0.01	150	5E-01	8E-01
USGS electronic	6436180	WWC	Site	4/26/1990	12:15:00 PM	Gaging Station	DISSOLVED	Copper	0.01	240	3E-01	6E-01
SDDENR electronic	460123	WWC	Site	1/13/1998	915	Water Quality Monitoring	Dissolved	Copper	0.005	637	1E-01	3E-01
SDDENR electronic	460123	WWC	Site	6/25/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	433	1E-01	3E-01
SDDENR electronic	460686	WWC	Site	7/21/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	254	2E-01	3E-01
USGS electronic	6436180	WWC	Site	12/22/1997	10:00:00 AM	Gaging Station	DISSOLVED	Copper	0.0028	480	6E-02	2E-01
SDDENR electronic	460685	WWC	Site	7/21/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.009	430	2E-01	5E-01
SDDENR electronic	460685	WWC	Site	10/27/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	407	1E-01	3E-01
SDDENR electronic	460123	WWC	Site	7/21/1997	1415	Water Quality Monitoring	Dissolved	Copper	0.008	468	2E-01	5E-01
USGS electronic	6436180	WWC	Site	8/17/1994	10:10:00 AM	Gaging Station	DISSOLVED	Copper	0.01	510	2E-01	6E-01
SDDENR electronic	460685	WWC	Site	4/21/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	248	2E-01	3E-01
USGS electronic	6436180	WWC	Site	1/16/1990	2:30:00 PM	Gaging Station	DISSOLVED	Copper	0.01	470	2E-01	6E-01
EPA (1999) - Aquatic	WWC-06	WWC	Site	9/1/1999	--	Field	Dissolved	Copper	0.0027	537	5E-02	2E-01
USGS electronic	6436180	WWC	Site	8/18/1993	10:30:00 AM	Gaging Station	DISSOLVED	Copper	0.005	490	1E-01	3E-01
USGS electronic	6436198	WWC	Site	7/20/1994	9:00:00 AM	Gaging Station	DISSOLVED	Copper	0.005	530	1E-01	3E-01
USGS electronic	6436198	WWC	Site	6/21/1994	9:30:00 AM	Gaging Station	DISSOLVED	Copper	0.005	570	1E-01	3E-01
USGS electronic	6436180	WWC	Site	5/10/1993	10:30:00 AM	Gaging Station	DISSOLVED	Copper	0.01	160	5E-01	7E-01
SDDENR electronic	460123	WWC	Site	2/18/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	480	1E-01	3E-01
SDDENR electronic	460685	WWC	Site	1/13/1998	840	Water Quality Monitoring	Dissolved	Copper	0.005	492	1E-01	3E-01
USGS electronic	6436180	WWC	Site	4/10/1991	12:45:00 PM	Gaging Station	DISSOLVED	Copper	0.01	360	2E-01	6E-01
USGS electronic	6436180	WWC	Site	9/11/1990	2:30:00 PM	Gaging Station	DISSOLVED	Copper	0.01	480	2E-01	6E-01
USGS electronic	6436180	WWC	Site	12/20/1994	9:10:00 AM	Gaging Station	DISSOLVED	Copper	0.005	500	1E-01	3E-01
EPA (1999) - Aquatic	WWC-R-01 M	WWC	Ref	9/1/1999	--	Field	Dissolved	Copper	0.0016	240	5E-02	9E-02
SDDENR electronic	460686	WWC	Site	4/21/1998	1320	Water Quality Monitoring	Dissolved	Copper	0.005	194	2E-01	3E-01
SDDENR electronic	460686	WWC	Site	1/13/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	257	2E-01	3E-01
USGS electronic	6436180	WWC	Site	7/20/1990	10:45:00 AM	Gaging Station	DISSOLVED	Copper	0.01	400	2E-01	6E-01
SDDENR electronic	460686	WWC	Site	10/27/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	257	2E-01	3E-01
USGS electronic	6436180	WWC	Site	6/20/1994	9:45:00 AM	Gaging Station	DISSOLVED	Copper	0.01	430	2E-01	6E-01
SDDENR electronic	460123	WWC	Site	5/27/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	288	1E-01	3E-01
USGS electronic	6436180	WWC	Site	7/11/1991	9:45:00 AM	Gaging Station	DISSOLVED	Copper	0.01	350	2E-01	6E-01
SDDENR electronic	460123	WWC	Site	10/27/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	348	1E-01	3E-01
SDDENR electronic	460123	WWC	Site	9/23/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	456	1E-01	3E-01
SDDENR electronic	460123	WWC	Site	8/18/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Copper	0.005	433	1E-01	3E-01
EPA (1999) - Aquatic	BFR-11	BFRd	Site	9/1/1999	--	Field	Dissolved	Copper	0.0014	661	3E-02	8E-02
USGS electronic	6436180	WWC	Site	10/9/1990	3:15:00 PM	Gaging Station	DISSOLVED	Copper	0.01	480	2E-01	6E-01
USGS electronic	6436198	WWC	Site	3/18/1993	9:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	650	7E-03	6E-02
USGS electronic	6436180	WWC	Site	12/20/1994	9:10:00 AM	Gaging Station	DISSOLVED	Aluminum	0.02	500	3E-02	2E-01
USGS electronic	6436180	WWC	Site	5/31/1990	9:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.09	300	1E-01	1E+00
USGS electronic	6436198	WWC	Site	6/5/1991	12:00:00 PM	Gaging Station	DISSOLVED	Aluminum	0.005	320	7E-03	6E-02
USGS electronic	6436180	WWC	Site	12/22/1997	10:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01601	480	2E-02	2E-01
USGS electronic	6436180	WWC	Site	11/27/1991	9:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	460	1E-02	1E-01
USGS electronic	6436198	WWC	Site	2/19/1993	10:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	690	7E-03	6E-02
USGS electronic	6436198	WWC	Site	7/10/1991	1:00:00 PM	Gaging Station	DISSOLVED	Aluminum	0.005	480	7E-03	6E-02
USGS electronic	6436198	WWC	Site	5/8/1991	10:45:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	430	7E-03	6E-02
USGS electronic	6436198	WWC	Site	1/7/1993	11:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	510	7E-03	6E-02

**APPENDIX E**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Aq SW COPCs	Adj Conc (mg/L)	Hardness (mg/L)	HQacute	HQchronic
USGS electronic	6436198	WWC	Site	8/14/1991	8:45:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	590	7E-03	6E-02
USGS electronic	6436180	WWC	Site	6/21/1990	6:00:00 PM	Gaging Station	DISSOLVED	Aluminum	0.01	400	1E-02	1E-01
USGS electronic	6436180	WWC	Site	9/12/1991	9:45:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	580	1E-02	1E-01
USGS electronic	6436198	WWC	Site	9/11/1991	8:15:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	630	7E-03	6E-02
USGS electronic	6436198	WWC	Site	12/9/1992	12:30:00 PM	Gaging Station	DISSOLVED	Aluminum	0.005	640	7E-03	6E-02
USGS electronic	6436180	WWC	Site	7/1/1991	9:45:00 AM	Gaging Station	DISSOLVED	Aluminum	0.03	350	4E-02	3E-01
USGS electronic	6436180	WWC	Site	12/13/1990	9:45:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	500	1E-02	1E-01
USGS electronic	6436198	WWC	Site	3/10/1992	9:15:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	530	7E-03	6E-02
USGS electronic	6436180	WWC	Site	5/7/1997	10:15:00 AM	Gaging Station	DISSOLVED	Aluminum	0.030235	150	4E-02	3E-01
USGS electronic	6436180	WWC	Site	3/6/1991	12:30:00 PM	Gaging Station	DISSOLVED	Aluminum	0.01	520	1E-02	1E-01
USGS electronic	6436180	WWC	Site	11/8/1990	10:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	500	1E-02	1E-01
USGS electronic	6436198	WWC	Site	4/9/1992	9:45:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	540	7E-03	6E-02
USGS electronic	6436180	WWC	Site	12/17/1991	1:45:00 PM	Gaging Station	DISSOLVED	Aluminum	0.01	520	1E-02	1E-01
USGS electronic	6436180	WWC	Site	1/23/1991	2:30:00 PM	Gaging Station	DISSOLVED	Aluminum	0.01	460	1E-02	1E-01
USGS electronic	6436180	WWC	Site	1/7/1997	10:15:00 AM	Gaging Station	DISSOLVED	Aluminum	0.0191	390	3E-02	2E-01
EPA (1999) - Aquatic	WWC-04	WWC	Site	9/1/1999	--	Field	Dissolved	Aluminum	0.0125	434	2E-02	1E-01
USGS electronic	6436198	WWC	Site	9/3/1992	7:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	590	7E-03	6E-02
USGS electronic	6436180	WWC	Site	10/22/1991	7:45:00 AM	Gaging Station	DISSOLVED	Aluminum	0.03	510	4E-02	3E-01
USGS electronic	6436180	WWC	Site	6/16/2000	7:50:00 AM	Water Quality Monitoring	Dissolved	Aluminum	0.023	na	3E-02	3E-01
USGS electronic	6436180	WWC	Site	4/26/1990	12:15:00 PM	Gaging Station	DISSOLVED	Aluminum	0.03	240	4E-02	3E-01
USGS electronic	6436180	WWC	Site	10/23/1996	9:10:00 AM	Gaging Station	DISSOLVED	Aluminum	0.022	490	3E-02	3E-01
USGS electronic	6436198	WWC	Site	6/12/1992	9:15:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	460	7E-03	6E-02
USGS electronic	6436180	WWC	Site	9/2/1998	9:40:00 AM	Gaging Station	DISSOLVED	Aluminum	0.02328	na	3E-02	3E-01
USGS electronic	6436180	WWC	Site	8/18/1993	10:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.02	490	3E-02	2E-01
USGS electronic	6436198	WWC	Site	9/13/2000	12:31:00 PM	Water Quality Monitoring	Dissolved	Aluminum	0.002	na	3E-03	2E-02
USGS electronic	6436198	WWC	Site	12/23/1997	9:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.00381	750	5E-03	4E-02
USGS electronic	6436198	WWC	Site	8/18/1994	9:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	640	7E-03	6E-02
USGS electronic	6436198	WWC	Site	4/29/1998	10:10:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01581	340	2E-02	2E-01
USGS electronic	6436180	WWC	Site	8/15/1991	8:15:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	510	1E-02	1E-01
USGS electronic	6436180	WWC	Site	7/14/1993	9:15:00 AM	Gaging Station	DISSOLVED	Aluminum	0.06	370	8E-02	7E-01
USGS electronic	6436180	WWC	Site	5/8/1996	8:40:00 AM	Gaging Station	DISSOLVED	Aluminum	0.03	190	4E-02	3E-01
USGS electronic	6436180	WWC	Site	6/15/1993	9:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	260	1E-02	1E-01
USGS electronic	6436198	WWC	Site	4/26/2000	11:55:00 AM	Water Quality Monitoring	Dissolved	Aluminum	0.012	na	2E-02	1E-01
USGS electronic	6436180	WWC	Site	8/17/1994	10:10:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	510	1E-02	1E-01
USGS electronic	6436180	WWC	Site	5/8/1995	6:45:00 PM	Gaging Station	DISSOLVED	Aluminum	0.005	110	7E-03	6E-02
USGS electronic	6436180	WWC	Site	5/5/1999	8:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.021975	na	3E-02	3E-01
USGS electronic	6436198	WWC	Site	7/15/1993	9:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	500	1E-01	4E-01
USGS electronic	6436198	WWC	Site	7/20/1994	9:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	530	7E-03	6E-02
USGS electronic	6436198	WWC	Site	12/21/1994	9:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	630	1E-02	1E-01
USGS electronic	6436198	WWC	Site	10/21/1991	10:45:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	620	1E-02	1E-01
EPA (1999) - Aquatic	WWC-05	WWC	Site	9/1/1999	--	Field	Dissolved	Aluminum	0.0125	496	2E-02	1E-01
USGS electronic	6436198	WWC	Site	11/17/1992	11:15:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	590	7E-03	6E-02
EPA (1999) - Aquatic	WWC-02	WWC	Site	9/1/1999	--	Field	Dissolved	Aluminum	0.0125	233	2E-02	1E-01
USGS electronic	6436198	WWC	Site	9/13/2000	12:30:00 PM	Water Quality Monitoring	Dissolved	Aluminum	0.002	na	3E-03	2E-02
USGS electronic	6436180	WWC	Site	6/3/1999	10:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.021256	na	3E-02	2E-01
USGS electronic	6436180	WWC	Site	4/21/1994	7:45:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	130	1E-02	1E-01
EPA (1999) - Aquatic	WWC-R-01 M	WWC	Ref	9/1/1999	--	Field	Dissolved	Aluminum	0.0125	240	2E-02	1E-01
USGS electronic	6436198	WWC	Site	2/15/1994	9:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	550	7E-03	6E-02
USGS electronic	6436180	WWC	Site	1/8/1996	12:30:00 PM	Gaging Station	DISSOLVED	Aluminum	0.03	450	4E-02	3E-01
USGS electronic	6436180	WWC	Site	12/27/1993	9:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	460	1E-02	1E-01
USGS electronic	6436198	WWC	Site	8/26/1997	12:30:00 PM	Gaging Station	DISSOLVED	Aluminum	0.011169	560	1E-02	1E-01
USGS electronic	6436180	WWC	Site	9/9/1993	7:45:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	490	1E-02	1E-01
USGS electronic	6436198	WWC	Site	9/1/1994	10:15:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	570	7E-03	6E-02
USGS electronic	6436180	WWC	Site	7/20/1990	10:45:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	400	1E-02	1E-01
USGS electronic	6436180	WWC	Site	2/14/1994	10:10:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	390	1E-02	1E-01
USGS electronic	6436198	WWC	Site	9/9/1993	10:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	630	7E-03	6E-02
USGS electronic	6436180	WWC	Site	2/12/1990	1:00:00 PM	Gaging Station	DISSOLVED	Aluminum	0.03	450	4E-02	3E-01
USGS electronic	6436198	WWC	Site	3/6/1991	8:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.02	450	3E-02	2E-01
USGS electronic	6436180	WWC	Site	3/29/1990	12:30:00 PM	Gaging Station	DISSOLVED	Aluminum	0.02	380	3E-02	2E-01
USGS electronic	6436180	WWC	Site	2/12/1992	10:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.02	540	3E-02	2E-01
USGS electronic	6436198	WWC	Site	4/15/1993	9:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.04	380	5E-02	5E-01
EPA (1999) - Aquatic	WWC-08	WWC	Site	9/1/1999	--	Field	Dissolved	Aluminum	0.0125	597	2E-02	1E-01
USGS electronic	6436198	WWC	Site	12/12/1990	11:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	590	7E-03	6E-02
USGS electronic	6436198	WWC	Site	5/6/1993	3:50:00 PM	Gaging Station	DISSOLVED	Aluminum	0.01	290	1E-02	1E-01
USGS electronic	6436198	WWC	Site	4/23/1990	9:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	330	7E-03	6E-02

**APPENDIX E**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Aq SW COPCs	Adj Conc (mg/L)	Hardness (mg/L)	HQacute	HQchronic
USGS electronic	6436180	WWC	Site	12/9/1992	9:20:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	560	1E-02	1E-01
USGS electronic	6436198	WWC	Site	12/28/1993	9:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	730	7E-03	6E-02
USGS electronic	6436198	WWC	Site	5/30/1990	10:45:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	400	7E-03	6E-02
EPA (1999) - Aquatic	BFR-11	BFRd	Site	9/1/1999	--	Field	Dissolved	Aluminum	0.0125	661	2E-02	1E-01
USGS electronic	6436198	WWC	Site	8/12/1992	8:45:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	550	7E-03	6E-02
USGS electronic	6436198	WWC	Site	4/10/1991	8:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	490	7E-03	6E-02
USGS electronic	6436180	WWC	Site	4/28/1992	12:30:00 PM	Gaging Station	DISSOLVED	Aluminum	0.01	270	1E-02	1E-01
EPA (1999) - Aquatic	BFR-R-10	BFRu	Ref	9/1/1999	--	Field	Dissolved	Aluminum	0.0125	678	2E-02	1E-01
USGS electronic	6436198	WWC	Site	6/16/1993	9:15:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	310	7E-03	6E-02
USGS electronic	6436198	WWC	Site	10/9/1990	11:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	540	7E-03	6E-02
USGS electronic	6436180	WWC	Site	6/11/1992	10:45:00 AM	Gaging Station	DISSOLVED	Aluminum	0.02	400	3E-02	2E-01
USGS electronic	6436180	WWC	Site	4/28/1998	10:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.03014	230	4E-02	3E-01
USGS electronic	6436198	WWC	Site	11/7/1990	12:15:00 PM	Gaging Station	DISSOLVED	Aluminum	0.005	580	7E-03	6E-02
USGS electronic	6436180	WWC	Site	3/11/1992	11:15:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	420	1E-02	1E-01
USGS electronic	6436180	WWC	Site	8/20/1996	9:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.0235	480	3E-02	3E-01
EPA (1999) - Aquatic	WWC-07	WWC	Site	9/1/1999	--	Field	Dissolved	Aluminum	0.0125	560	2E-02	1E-01
USGS electronic	6436198	WWC	Site	5/10/1993	3:30:00 PM	Gaging Station	DISSOLVED	Aluminum	0.005	250	7E-03	6E-02
USGS electronic	6436180	WWC	Site	6/9/1998	9:05:00 AM	Gaging Station	DISSOLVED	Aluminum	0.02603	380	3E-02	3E-01
USGS electronic	6436180	WWC	Site	4/8/1992	2:15:00 PM	Gaging Station	DISSOLVED	Aluminum	0.03	450	4E-02	3E-01
USGS electronic	6436198	WWC	Site	7/15/1993	9:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.04	500	5E-02	5E-01
USGS electronic	6436180	WWC	Site	1/16/1990	2:30:00 PM	Gaging Station	DISSOLVED	Aluminum	0.02	470	3E-02	2E-01
USGS electronic	6436198	WWC	Site	9/13/1999	12:25:00 PM	Gaging Station	DISSOLVED	Aluminum	0.002056	na	3E-03	2E-02
EPA (1999) - Aquatic	SPC-R-12	OTHER	Ref	9/1/1999	--	Field	Dissolved	Aluminum	0.0125	292	2E-02	1E-01
USGS electronic	6436180	WWC	Site	6/11/1991	8:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	240	1E-02	1E-01
USGS electronic	6436180	WWC	Site	4/10/1991	12:45:00 PM	Gaging Station	DISSOLVED	Aluminum	0.02	360	3E-02	2E-01
USGS electronic	6436180	WWC	Site	1/16/1992	9:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	530	1E-02	1E-01
USGS electronic	6436198	WWC	Site	11/26/1991	9:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	600	7E-03	6E-02
USGS electronic	6436180	WWC	Site	9/11/1990	2:30:00 PM	Gaging Station	DISSOLVED	Aluminum	0.01	480	1E-02	1E-01
USGS electronic	6436198	WWC	Site	5/25/1996	1:45:00 PM	Gaging Station	DISSOLVED	Aluminum	0.02	310	3E-02	2E-01
EPA (1999) - Aquatic	WWC-08	WWC	Site	9/1/1999	--	Duplicate	Dissolved	Aluminum	0.0125	606	2E-02	1E-01
USGS electronic	6436198	WWC	Site	10/14/1992	8:45:00 AM	Gaging Station	DISSOLVED	Aluminum	0.02	570	3E-02	2E-01
USGS electronic	6436180	WWC	Site	8/11/1992	8:45:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	580	1E-02	1E-01
USGS electronic	6436180	WWC	Site	8/26/1997	8:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.03592	410	5E-02	4E-01
USGS electronic	6436198	WWC	Site	1/15/1992	1:30:00 PM	Gaging Station	DISSOLVED	Aluminum	0.005	780	7E-03	6E-02
USGS electronic	6436180	WWC	Site	5/9/1991	8:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.02	330	3E-02	2E-01
USGS electronic	6436180	WWC	Site	8/15/1990	9:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.03	440	4E-02	3E-01
USGS electronic	6436198	WWC	Site	2/11/1992	11:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	660	1E-02	1E-01
USGS electronic	6436198	WWC	Site	5/8/1996	1:30:00 PM	Gaging Station	DISSOLVED	Aluminum	0.02	360	3E-02	2E-01
EPA (1999) - Aquatic	WWC-03	WWC	Site	9/1/1999	--	Field	Dissolved	Aluminum	0.0125	499	2E-02	1E-01
USGS electronic	6436198	WWC	Site	4/29/1992	9:15:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	340	1E-02	1E-01
USGS electronic	6436180	WWC	Site	11/16/1992	10:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	560	1E-02	1E-01
USGS electronic	6436180	WWC	Site	12/29/1999	9:20:00 AM	Water Quality Monitoring	Dissolved	Aluminum	0.014	na	2E-02	2E-01
USGS electronic	6436180	WWC	Site	7/14/1992	11:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.02	440	3E-02	2E-01
USGS electronic	6436198	WWC	Site	6/21/1990	12:15:00 PM	Gaging Station	DISSOLVED	Aluminum	0.005	460	7E-03	6E-02
USGS electronic	6436198	WWC	Site	9/11/1990	9:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	560	7E-03	6E-02
USGS electronic	6436180	WWC	Site	10/13/1992	11:15:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	540	1E-02	1E-01
USGS electronic	6436180	WWC	Site	4/26/2000	8:30:00 AM	Water Quality Monitoring	Dissolved	Aluminum	0.029	na	4E-02	3E-01
USGS electronic	6436198	WWC	Site	7/19/1990	9:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	490	7E-03	6E-02
EPA (1999) - Aquatic	WWC-06	WWC	Site	9/1/1999	--	Field	Dissolved	Aluminum	0.0125	537	2E-02	1E-01
USGS electronic	6436180	WWC	Site	9/13/2000	10:00:00 AM	Water Quality Monitoring	Dissolved	Aluminum	0.003	na	4E-03	3E-02
USGS electronic	6436180	WWC	Site	6/25/1996	11:05:00 AM	Gaging Station	DISSOLVED	Aluminum	0.0379	340	5E-02	4E-01
USGS electronic	6436198	WWC	Site	8/16/1990	11:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	570	7E-03	6E-02
USGS electronic	6436180	WWC	Site	9/2/1992	11:45:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	510	1E-02	1E-01
USGS electronic	6436198	WWC	Site	8/19/1993	10:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	630	7E-03	6E-02
USGS electronic	6436180	WWC	Site	10/9/1990	3:15:00 PM	Gaging Station	DISSOLVED	Aluminum	0.01	480	1E-02	1E-01
USGS electronic	6436198	WWC	Site	12/17/1991	9:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	680	7E-03	6E-02
USGS electronic	6436198	WWC	Site	6/16/2000	11:35:00 AM	Water Quality Monitoring	Dissolved	Selenium	0.0026	na	1E-01	6E-01
USGS electronic	6436198	WWC	Site	6/26/1996	8:10:00 AM	Gaging Station	DISSOLVED	Aluminum	0.0076	640	1E-02	9E-02
USGS electronic	6436180	WWC	Site	12/20/1994	9:10:00 AM	Gaging Station	DISSOLVED	Selenium	0.003	500	2E-01	7E-01
USGS electronic	6436198	WWC	Site	9/13/2000	12:31:00 PM	Water Quality Monitoring	Dissolved	Selenium	0.0025	na	1E-01	5E-01
USGS electronic	6436180	WWC	Site	12/22/1997	10:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.0028	480	2E-01	6E-01
USGS electronic	6436198	WWC	Site	9/13/2000	12:30:00 PM	Water Quality Monitoring	Dissolved	Selenium	0.0025	na	1E-01	5E-01
USGS electronic	6436198	WWC	Site	7/19/1990	9:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.0005	490	3E-02	1E-01
USGS electronic	6436180	WWC	Site	2/14/1994	10:10:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	390	1E-01	4E-01
USGS electronic	6436180	WWC	Site	6/20/1994	9:45:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	430	1E-01	4E-01

**APPENDIX E**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Aq SW COPCs	Adj Conc (mg/L)	Hardness (mg/L)	HQacute	HQchronic
USGS electronic	6436198	WWC	Site	4/26/2000	11:55:00 AM	Water Quality Monitoring	Dissolved	Selenium	0.0013	na	7E-02	3E-01
USGS electronic	6436180	WWC	Site	9/7/1994	9:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.004	510	2E-01	9E-01
USGS electronic	6436198	WWC	Site	12/29/1999	12:15:00 PM	Water Quality Monitoring	Dissolved	Selenium	0.0018	na	1E-01	4E-01
USGS electronic	6436180	WWC	Site	5/24/1994	11:10:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	290	1E-01	4E-01
USGS electronic	6436198	WWC	Site	11/7/1990	12:15:00 PM	Gaging Station	DISSOLVED	Selenium	0.0005	580	3E-02	1E-01
USGS electronic	6436180	WWC	Site	7/20/1990	10:45:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	400	1E-01	4E-01
USGS electronic	6436180	WWC	Site	8/30/1995	8:01:00 AM	Gaging Station	DISSOLVED	Selenium	0.003	410	2E-01	7E-01
USGS electronic	6436180	WWC	Site	3/6/1991	12:30:00 PM	Gaging Station	DISSOLVED	Selenium	0.001	520	6E-02	2E-01
USGS electronic	6436198	WWC	Site	2/12/1990	9:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	520	1E-01	4E-01
USGS electronic	6436180	WWC	Site	6/21/1990	6:00:00 PM	Gaging Station	DISSOLVED	Selenium	0.003	400	2E-01	7E-01
EPA (1999) - Aquatic	WWC-09	WWC	Site	9/1/1999	--	Duplicate	Dissolved	Selenium	0.001	694	6E-02	2E-01
USGS electronic	6436180	WWC	Site	5/7/1997	10:15:00 AM	Gaging Station	DISSOLVED	Selenium	0.0005	150	3E-02	1E-01
USGS electronic	6436180	WWC	Site	9/11/1990	2:30:00 PM	Gaging Station	DISSOLVED	Selenium	0.004	480	2E-01	9E-01
USGS electronic	6436180	WWC	Site	5/9/1991	8:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.003	330	2E-01	7E-01
USGS electronic	6436198	WWC	Site	9/11/1990	9:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.0005	560	3E-02	1E-01
USGS electronic	6436180	WWC	Site	12/27/1993	9:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	460	1E-01	4E-01
EPA (1999) - Aquatic	WWC-R-01 M	WWC	Ref	9/1/1999	--	Field	Dissolved	Selenium	0.0049	240	3E-01	1E+00
USGS electronic	6436180	WWC	Site	1/8/1996	12:30:00 PM	Gaging Station	DISSOLVED	Selenium	0.002	450	1E-01	4E-01
USGS electronic	6436180	WWC	Site	7/19/1994	9:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.003	450	2E-01	7E-01
USGS electronic	6436180	WWC	Site	10/9/1990	3:15:00 PM	Gaging Station	DISSOLVED	Selenium	0.002	480	1E-01	4E-01
USGS electronic	6436198	WWC	Site	10/9/1990	11:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.001	540	6E-02	2E-01
USGS electronic	6436180	WWC	Site	11/8/1990	10:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.003	500	2E-01	7E-01
USGS electronic	6436180	WWC	Site	9/1/1994	8:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.004	460	2E-01	9E-01
USGS electronic	6436198	WWC	Site	5/25/1996	1:45:00 PM	Gaging Station	DISSOLVED	Selenium	0.0005	310	3E-02	1E-01
USGS electronic	6436180	WWC	Site	12/16/1998	10:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.00226	na	1E-01	5E-01
USGS electronic	6436180	WWC	Site	8/15/1991	8:15:00 AM	Gaging Station	DISSOLVED	Selenium	0.004	510	2E-01	9E-01
USGS electronic	6436198	WWC	Site	5/8/1991	10:45:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	430	1E-01	4E-01
USGS electronic	6436180	WWC	Site	4/26/2000	8:30:00 AM	Water Quality Monitoring	Dissolved	Selenium	0.0009	na	5E-02	2E-01
USGS electronic	6436198	WWC	Site	6/16/1993	9:15:00 AM	Gaging Station	DISSOLVED	Selenium	0.001	310	6E-02	2E-01
USGS electronic	6436180	WWC	Site	5/24/1995	8:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	270	1E-01	4E-01
EPA (1999) - Aquatic	WWC-03	WWC	Site	9/1/1999	--	Field	Dissolved	Selenium	0.0055	499	3E-01	1E+00
EPA (1999) - Aquatic	BFR-R-10	BFRu	Ref	9/1/1999	--	Field	Dissolved	Selenium	0.005	678	3E-01	1E+00
USGS electronic	6436198	WWC	Site	10/21/1991	10:45:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	620	1E-01	4E-01
USGS electronic	6436198	WWC	Site	4/21/1994	1:00:00 PM	Gaging Station	DISSOLVED	Selenium	0.001	180	6E-02	2E-01
USGS electronic	6436180	WWC	Site	5/5/1999	8:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.00055	na	3E-02	1E-01
USGS electronic	6436198	WWC	Site	7/10/1991	1:00:00 PM	Gaging Station	DISSOLVED	Selenium	0.003	480	2E-01	7E-01
USGS electronic	6436198	WWC	Site	5/25/1994	10:20:00 AM	Gaging Station	DISSOLVED	Selenium	0.001	400	6E-02	2E-01
USGS electronic	6436198	WWC	Site	1/15/1992	1:30:00 PM	Gaging Station	DISSOLVED	Copper	0.005	780	1E-01	3E-01
USGS electronic	6436198	WWC	Site	6/12/1992	9:15:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	460	1E-01	4E-01
USGS electronic	6436180	WWC	Site	4/8/1992	2:15:00 PM	Gaging Station	DISSOLVED	Selenium	0.003	450	2E-01	7E-01
USGS electronic	6436180	WWC	Site	8/15/1990	9:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	440	1E-01	4E-01
USGS electronic	6436180	WWC	Site	12/13/1990	9:45:00 AM	Gaging Station	DISSOLVED	Selenium	0.003	500	2E-01	7E-01
USGS electronic	6436180	WWC	Site	3/29/1990	12:30:00 PM	Gaging Station	DISSOLVED	Selenium	0.002	380	1E-01	4E-01
USGS electronic	6436198	WWC	Site	3/29/1990	8:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	480	1E-01	4E-01
USGS electronic	6436198	WWC	Site	6/21/1990	12:15:00 PM	Gaging Station	DISSOLVED	Selenium	0.002	460	1E-01	4E-01
USGS electronic	6436198	WWC	Site	11/26/1991	9:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.0005	600	3E-02	1E-01
USGS electronic	6436180	WWC	Site	1/16/1992	9:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.003	530	2E-01	7E-01
USGS electronic	6436198	WWC	Site	6/21/1994	9:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	570	1E-01	4E-01
USGS electronic	6436180	WWC	Site	6/11/1992	10:45:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	400	1E-01	4E-01
USGS electronic	6436198	WWC	Site	6/9/1998	12:35:00 PM	Gaging Station	DISSOLVED	Selenium	0.00165	490	9E-02	4E-01
USGS electronic	6436198	WWC	Site	8/19/1993	10:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.001	630	6E-02	2E-01
USGS electronic	6436198	WWC	Site	5/8/1996	1:30:00 PM	Gaging Station	DISSOLVED	Selenium	0.001	360	6E-02	2E-01
USGS electronic	6436198	WWC	Site	4/9/1992	9:45:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	540	1E-01	4E-01
USGS electronic	6436180	WWC	Site	6/16/2000	7:50:00 AM	Water Quality Monitoring	Dissolved	Selenium	0.0021	na	1E-01	5E-01
USGS electronic	6436180	WWC	Site	8/26/1997	8:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.0023	410	1E-01	5E-01
USGS electronic	6436198	WWC	Site	9/2/1998	1:25:00 PM	Gaging Station	DISSOLVED	Selenium	0.00198	na	1E-01	4E-01
USGS electronic	6436198	WWC	Site	9/2/1998	1:25:00 PM	Gaging Station	DISSOLVED	Aluminum	0.00693	na	9E-03	8E-02
USGS electronic	6436180	WWC	Site	9/1/1994	8:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	460	1E-02	1E-01
USGS electronic	6436198	WWC	Site	2/12/1990	9:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	520	7E-03	6E-02
USGS electronic	6436198	WWC	Site	5/25/1994	10:20:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	400	7E-03	6E-02
USGS electronic	6436180	WWC	Site	4/14/1993	9:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.02	260	3E-02	2E-01
USGS electronic	6436198	WWC	Site	3/16/1994	9:45:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	380	7E-03	6E-02
USGS electronic	6436180	WWC	Site	5/25/1996	10:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.02	210	3E-02	2E-01
USGS electronic	6436180	WWC	Site	3/17/1993	9:45:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	530	1E-02	1E-01
USGS electronic	6436180	WWC	Site	5/24/1994	11:10:00 AM	Gaging Station	DISSOLVED	Aluminum	0.03	290	4E-02	3E-01

**APPENDIX E**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Aq SW COPCs	Adj Conc (mg/L)	Hardness (mg/L)	HQacute	HQchronic
EPA (1999) - Aquatic	WWC-09	WWC	Site	9/1/1999	--	Duplicate	Dissolved	Aluminum	0.068	694	9E-02	8E-01
USGS electronic	6436198	WWC	Site	1/17/1990	10:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	580	7E-03	6E-02
USGS electronic	6436180	WWC	Site	5/6/1993	1:15:00 PM	Gaging Station	DISSOLVED	Aluminum	0.02	170	3E-02	2E-01
EPA (1999) - Aquatic	WWC-09	WWC	Site	9/1/1999	--	Field	Dissolved	Aluminum	0.055	704	7E-02	6E-01
USGS electronic	6436198	WWC	Site	5/5/1999	10:45:00 AM	Gaging Station	DISSOLVED	Aluminum	0.008747	na	1E-02	1E-01
USGS electronic	6436180	WWC	Site	7/14/1993	9:15:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	370	1E-01	4E-01
USGS electronic	6436180	WWC	Site	2/18/1993	10:45:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	580	1E-02	1E-01
USGS electronic	6436180	WWC	Site	7/19/1994	9:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.03	450	4E-02	3E-01
USGS electronic	6436180	WWC	Site	5/24/1995	8:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.03	270	4E-02	3E-01
USGS electronic	6436180	WWC	Site	9/7/1994	9:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.02	510	3E-02	2E-01
USGS electronic	6436198	WWC	Site	8/20/1996	12:15:00 PM	Gaging Station	DISSOLVED	Aluminum	0.0025	670	3E-03	3E-02
USGS electronic	6436198	WWC	Site	1/9/1996	11:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	710	7E-03	6E-02
USGS electronic	6436180	WWC	Site	3/15/1994	10:15:00 AM	Gaging Station	DISSOLVED	Aluminum	0.03	250	4E-02	3E-01
USGS electronic	6436198	WWC	Site	10/24/1996	9:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.014	670	2E-02	2E-01
USGS electronic	6436198	WWC	Site	6/16/2000	11:35:00 AM	Water Quality Monitoring	Dissolved	Aluminum	0.013	na	2E-02	1E-01
USGS electronic	6436198	WWC	Site	8/30/1995	12:15:00 PM	Gaging Station	DISSOLVED	Aluminum	0.005	740	7E-03	6E-02
USGS electronic	6436198	WWC	Site	5/9/1995	8:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.04	280	5E-02	5E-01
USGS electronic	6436198	WWC	Site	1/8/1997	10:20:00 AM	Gaging Station	DISSOLVED	Aluminum	0.0062	590	8E-03	7E-02
USGS electronic	6436180	WWC	Site	12/16/1998	10:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.016017	na	2E-02	2E-01
USGS electronic	6436180	WWC	Site	8/30/1995	8:01:00 AM	Gaging Station	DISSOLVED	Aluminum	0.03	410	4E-02	3E-01
USGS electronic	6436180	WWC	Site	6/20/1994	9:45:00 AM	Gaging Station	DISSOLVED	Aluminum	0.06	430	8E-02	7E-01
USGS electronic	6436198	WWC	Site	5/24/1995	12:00:00 PM	Gaging Station	DISSOLVED	Aluminum	0.02	530	3E-02	2E-01
USGS electronic	6436180	WWC	Site	1/6/1993	11:45:00 AM	Gaging Station	DISSOLVED	Aluminum	0.01	320	1E-02	1E-01
USGS electronic	6436198	WWC	Site	5/8/1997	9:00:00 AM	Gaging Station	DISSOLVED	Aluminum	0.013988	230	2E-02	2E-01
USGS electronic	6436180	WWC	Site	4/21/1994	7:45:00 AM	Gaging Station	DISSOLVED	Selenium	0.001	130	6E-02	2E-01
USGS electronic	6436180	WWC	Site	8/18/1993	10:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	490	1E-01	4E-01
USGS electronic	6436180	WWC	Site	1/23/1991	2:30:00 PM	Gaging Station	DISSOLVED	Selenium	0.002	460	1E-01	4E-01
USGS electronic	6436198	WWC	Site	8/16/1990	11:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	570	1E-01	4E-01
EPA (1999) - Aquatic	WWC-08	WWC	Site	9/1/1999	--	Field	Dissolved	Selenium	0.0068	597	4E-01	1E+00
EPA (1999) - Aquatic	WWC-07	WWC	Site	9/1/1999	--	Field	Dissolved	Selenium	0.0074	560	4E-01	2E+00
USGS electronic	6436180	WWC	Site	9/13/1999	8:15:00 AM	Gaging Station	DISSOLVED	Aluminum	0.016245	na	2E-02	2E-01
USGS electronic	6436180	WWC	Site	6/15/1993	9:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.001	260	6E-02	2E-01
EPA (1999) - Aquatic	WWC-08	WWC	Site	9/1/1999	--	Duplicate	Dissolved	Selenium	0.0063	606	4E-01	1E+00
USGS electronic	6436198	WWC	Site	5/30/1990	10:45:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	400	1E-01	4E-01
USGS electronic	6436180	WWC	Site	4/26/1990	12:15:00 PM	Gaging Station	DISSOLVED	Selenium	0.002	240	1E-01	4E-01
USGS electronic	6436198	WWC	Site	1/17/1990	10:00:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	580	1E-01	4E-01
EPA (1999) - Aquatic	WWC-09	WWC	Site	9/1/1999	--	Extra (collocated with fish sample)	Dissolved	Selenium	0.001	681	6E-02	2E-01
USGS electronic	6436180	WWC	Site	3/15/1994	10:15:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	250	1E-01	4E-01
USGS electronic	6436198	WWC	Site	5/24/1995	12:00:00 PM	Gaging Station	DISSOLVED	Selenium	0.002	530	1E-01	4E-01
USGS electronic	6436198	WWC	Site	4/23/1990	9:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.001	330	6E-02	2E-01
USGS electronic	6436198	WWC	Site	12/29/1999	12:15:00 PM	Water Quality Monitoring	Dissolved	Aluminum	0.001	na	1E-03	1E-02
USGS electronic	6436198	WWC	Site	12/16/1998	2:15:00 PM	Gaging Station	DISSOLVED	Aluminum	0.00281	na	4E-03	3E-02
EPA (1999) - Aquatic	WWC-09	WWC	Site	9/1/1999	--	Extra (collocated with fish sample)	Dissolved	Aluminum	0.015	681	2E-02	2E-01
USGS electronic	6436198	WWC	Site	6/21/1994	9:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.02	570	3E-02	2E-01
USGS electronic	6436198	WWC	Site	6/3/1999	2:00:00 PM	Gaging Station	DISSOLVED	Aluminum	0.013767	na	2E-02	2E-01
USGS electronic	6436198	WWC	Site	6/9/1998	12:35:00 PM	Gaging Station	DISSOLVED	Aluminum	0.0139	490	2E-02	2E-01
USGS electronic	6436180	WWC	Site	5/10/1993	10:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.02	160	3E-02	2E-01
USGS electronic	6436180	WWC	Site	5/8/1995	6:45:00 PM	Gaging Station	DISSOLVED	Selenium	0.0005	110	3E-02	1E-01
USGS electronic	6436198	WWC	Site	4/21/1994	1:00:00 PM	Gaging Station	DISSOLVED	Aluminum	0.005	180	7E-03	6E-02
USGS electronic	6436180	WWC	Site	8/17/1994	10:10:00 AM	Gaging Station	DISSOLVED	Selenium	0.004	510	2E-01	9E-01
USGS electronic	6436180	WWC	Site	6/11/1991	8:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.001	240	6E-02	2E-01
USGS electronic	6436180	WWC	Site	4/10/1991	12:45:00 PM	Gaging Station	DISSOLVED	Selenium	0.003	360	2E-01	7E-01
USGS electronic	6436198	WWC	Site	12/12/1990	11:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.001	590	6E-02	2E-01
USGS electronic	6436180	WWC	Site	9/9/1993	7:45:00 AM	Gaging Station	DISSOLVED	Selenium	0.001	490	6E-02	2E-01
USGS electronic	6436180	WWC	Site	5/31/1990	9:30:00 AM	Gaging Station	DISSOLVED	Selenium	0.002	300	1E-01	4E-01
EPA (1999) - Aquatic	WWC-09	WWC	Site	9/1/1999	--	Field	Dissolved	Selenium	0.001	704	6E-02	2E-01
USGS electronic	6436198	WWC	Site	3/29/1990	8:30:00 AM	Gaging Station	DISSOLVED	Aluminum	0.005	480	7E-03	6E-02
USGS electronic	6436198	WWC	Site	3/10/1992	9:15:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	530	1E-02	na
USGS electronic	6436198	WWC	Site	12/28/1993	9:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	730	1E-02	na
SDDENR electronic	460123	WWC	Site	5/12/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.005	295	2E-01	na
SDDENR electronic	460123	WWC	Site	4/21/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.005	247	3E-01	na
SDDENR electronic	460123	WWC	Site	3/24/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.005	408	1E-01	na
USGS electronic	6436180	WWC	Site	6/11/1992	10:45:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	400	1E-02	na
USGS electronic	6436198	WWC	Site	9/9/1993	10:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	630	1E-02	na
USGS electronic	6436180	WWC	Site	4/28/1998	10:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	230	3E-02	na

**APPENDIX E**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Aq SW COPCs	Adj Conc (mg/L)	Hardness (mg/L)	HQacute	HQchronic
SDDENR electronic	460684	WWC	Site	10/28/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.005	547	1E-01	na
USGS electronic	6436198	WWC	Site	10/24/1996	9:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	670	1E-02	na
USGS electronic	6436180	WWC	Site	5/24/1995	8:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	270	3E-02	na
EPA (1999) - Aquatic	WWC-09	WWC	Site	9/1/1999	--	Duplicate	Dissolved	Silver	0.0025	694	7E-02	na
SDDENR electronic	460684	WWC	Site	5/12/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.005	281	2E-01	na
USGS electronic	6436198	WWC	Site	2/11/1992	11:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	660	1E-02	na
USGS electronic	6436180	WWC	Site	1/8/1996	12:30:00 PM	Gaging Station	DISSOLVED	Silver	0.0005	450	1E-02	na
SDDENR electronic	460123	WWC	Site	5/27/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	288	1E-01	na
USGS electronic	6436198	WWC	Site	9/11/1990	9:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	560	1E-02	na
EPA (1999) - Aquatic	BFR-11	BFRd	Site	9/1/1999	--	Field	Dissolved	Silver	0.0005	661	1E-02	na
USGS electronic	6436180	WWC	Site	2/18/1993	10:45:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	580	1E-02	na
EPA (1999) - Aquatic	WWC-06	WWC	Site	9/1/1999	--	Field	Dissolved	Silver	0.0014	537	4E-02	na
USGS electronic	6436180	WWC	Site	8/17/1994	10:10:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	510	1E-02	na
USGS electronic	6436198	WWC	Site	8/20/1996	12:15:00 PM	Gaging Station	DISSOLVED	Silver	0.0005	670	1E-02	na
USGS electronic	6436180	WWC	Site	8/20/1996	9:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	480	1E-02	na
USGS electronic	6436180	WWC	Site	7/14/1993	9:15:00 AM	Gaging Station	DISSOLVED	Silver	0.001	370	3E-02	na
USGS electronic	6436180	WWC	Site	7/20/1990	10:45:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	400	1E-02	na
USGS electronic	6436198	WWC	Site	6/16/1993	9:15:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	310	2E-02	na
EPA (1999) - Aquatic	WWC-04	WWC	Site	9/1/1999	--	Field	Dissolved	Silver	0.0011	434	3E-02	na
USGS electronic	6436180	WWC	Site	8/15/1991	8:15:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	510	1E-02	na
USGS electronic	6436180	WWC	Site	3/15/1994	10:15:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	250	3E-02	na
USGS electronic	6436180	WWC	Site	6/20/1994	9:45:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	430	1E-02	na
SDDENR electronic	460685	WWC	Site	7/21/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.03	430	8E-01	na
SDDENR electronic	460685	WWC	Site	4/21/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.02	248	1E+00	na
EPA (1999) - Aquatic	WWC-09	WWC	Site	9/1/1999	--	Field	Dissolved	Silver	0.0025	704	7E-02	na
USGS electronic	6436180	WWC	Site	1/23/1991	2:30:00 PM	Gaging Station	DISSOLVED	Silver	0.0005	460	1E-02	na
USGS electronic	6436198	WWC	Site	3/6/1991	8:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	450	1E-02	na
SDDENR electronic	460684	WWC	Site	4/20/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.005	270	3E-01	na
USGS electronic	6436180	WWC	Site	9/12/1991	9:45:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	580	1E-02	na
USGS electronic	6436198	WWC	Site	1/7/1993	11:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	510	1E-02	na
USGS electronic	6436180	WWC	Site	6/15/1993	9:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	260	3E-02	na
USGS electronic	6436198	WWC	Site	3/18/1993	9:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	650	1E-02	na
USGS electronic	6436180	WWC	Site	9/11/1990	2:30:00 PM	Gaging Station	DISSOLVED	Silver	0.0005	480	1E-02	na
USGS electronic	6436180	WWC	Site	5/8/1995	6:45:00 PM	Gaging Station	DISSOLVED	Silver	0.001	110	2E-01	na
USGS electronic	6436180	WWC	Site	5/24/1994	11:10:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	290	2E-02	na
SDDENR electronic	460122	WWC	Site	6/25/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.005	447	2E-02	1E+00
SDDENR electronic	460684	WWC	Site	8/18/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	389	7E-02	na
SDDENR electronic	460123	WWC	Site	8/18/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	433	7E-02	na
USGS electronic	6436198	WWC	Site	11/17/1992	11:15:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	590	1E-02	na
USGS electronic	6436198	WWC	Site	12/9/1992	12:30:00 PM	Gaging Station	DISSOLVED	Silver	0.0005	640	1E-02	na
SDDENR electronic	460684	WWC	Site	9/23/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.005	431	1E-01	na
SDDENR electronic	460684	WWC	Site	1/14/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	606	7E-02	na
USGS electronic	6436180	WWC	Site	6/25/1996	11:05:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	340	2E-02	na
SDDENR electronic	460685	WWC	Site	10/27/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.01	407	3E-01	na
SDDENR electronic	460684	WWC	Site	11/24/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	451	7E-02	na
SDDENR electronic	460685	WWC	Site	1/13/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.005	492	1E-01	na
USGS electronic	6436180	WWC	Site	1/7/1997	10:15:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	390	1E-02	na
USGS electronic	6436198	WWC	Site	5/25/1996	1:45:00 PM	Gaging Station	DISSOLVED	Silver	0.0005	310	2E-02	na
SDDENR electronic	460684	WWC	Site	2/18/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.005	393	1E-01	na
USGS electronic	6436198	WWC	Site	1/23/1991	8:45:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	680	1E-02	na
USGS electronic	6436180	WWC	Site	10/13/1992	11:15:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	540	1E-02	na
SDDENR electronic	460684	WWC	Site	3/24/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.005	366	2E-01	na
SDDENR electronic	460684	WWC	Site	12/16/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	218	2E-01	na
USGS electronic	6436180	WWC	Site	4/21/1994	7:45:00 AM	Gaging Station	DISSOLVED	Lead	0.02	130	2E-01	6E+00
USGS electronic	6436180	WWC	Site	1/8/1996	12:30:00 PM	Gaging Station	DISSOLVED	Lead	0.005	450	2E-02	1E+00
SDDENR electronic	460684	WWC	Site	12/16/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.005	218	3E-02	1E+00
USGS electronic	6436198	WWC	Site	8/16/1990	11:00:00 AM	Gaging Station	DISSOLVED	Lead	0.005	570	2E-02	1E+00
USGS electronic	6436180	WWC	Site	5/25/1996	10:00:00 AM	Gaging Station	DISSOLVED	Lead	0.01	210	7E-02	3E+00
USGS electronic	6436180	WWC	Site	4/14/1993	9:30:00 AM	Gaging Station	DISSOLVED	Lead	0.005	260	3E-02	1E+00
USGS electronic	6436180	WWC	Site	5/7/1997	10:15:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	150	7E-02	na
USGS electronic	6436180	WWC	Site	8/17/1994	10:10:00 AM	Gaging Station	DISSOLVED	Lead	0.01	510	4E-02	3E+00
SDDENR electronic	460122	WWC	Site	8/18/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	449	4E-03	3E-01
USGS electronic	6436198	WWC	Site	9/11/1991	8:15:00 AM	Gaging Station	DISSOLVED	Lead	0.005	630	2E-02	1E+00
USGS electronic	6436180	WWC	Site	8/15/1990	9:00:00 AM	Gaging Station	DISSOLVED	Lead	0.01	440	4E-02	3E+00
SDDENR electronic	460685	WWC	Site	4/21/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	248	6E-03	3E-01

**APPENDIX E**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Aq SW COPCs	Adj Conc (mg/L)	Hardness (mg/L)	HQacute	HQchronic
USGS electronic	6436180	WWC	Site	1/6/1993	11:45:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	320	2E-02	na
USGS electronic	6436198	WWC	Site	4/9/1992	9:45:00 AM	Gaging Station	DISSOLVED	Silver	0.001	540	3E-02	na
SDDENR electronic	460123	WWC	Site	6/25/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	433	7E-02	na
SDDENR electronic	460122	WWC	Site	1/13/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.005	673	2E-02	1E+00
USGS electronic	6436180	WWC	Site	7/14/1992	11:00:00 AM	Gaging Station	DISSOLVED	Copper	0.01	440	2E-01	6E-01
SDDENR electronic	460122	WWC	Site	7/21/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.003	480	1E-02	8E-01
SDDENR electronic	460123	WWC	Site	1/13/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.005	637	2E-02	1E+00
EPA (1999) - Aquatic	WWC-05	WWC	Site	9/1/1999	--	Field	Dissolved	Lead	0.001	496	4E-03	3E-01
SDDENR electronic	460123	WWC	Site	12/16/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.005	251	3E-02	1E+00
USGS electronic	6436198	WWC	Site	1/15/1992	1:30:00 PM	Gaging Station	DISSOLVED	Lead	0.005	780	2E-02	1E+00
SDDENR electronic	460122	WWC	Site	3/24/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	486	4E-03	3E-01
USGS electronic	6436180	WWC	Site	3/15/1994	10:15:00 AM	Gaging Station	DISSOLVED	Lead	0.01	250	6E-02	3E+00
USGS electronic	6436198	WWC	Site	8/14/1991	8:45:00 AM	Gaging Station	DISSOLVED	Lead	0.005	590	2E-02	1E+00
SDDENR electronic	460122	WWC	Site	5/27/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	301	5E-03	3E-01
USGS electronic	6436180	WWC	Site	7/14/1993	9:15:00 AM	Gaging Station	DISSOLVED	Lead	0.01	370	4E-02	3E+00
SDDENR electronic	460685	WWC	Site	10/27/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	407	4E-03	3E-01
SDDENR electronic	460122	WWC	Site	4/21/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	240	6E-03	3E-01
USGS electronic	6436198	WWC	Site	5/8/1996	1:30:00 PM	Gaging Station	DISSOLVED	Silver	0.0005	360	2E-02	na
SDDENR electronic	460123	WWC	Site	12/16/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	251	1E-01	na
SDDENR electronic	460123	WWC	Site	10/27/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.005	348	2E-01	na
USGS electronic	6436198	WWC	Site	1/9/1996	11:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	710	1E-02	na
SDDENR electronic	460123	WWC	Site	9/23/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.005	456	1E-01	na
USGS electronic	6436180	WWC	Site	7/14/1992	11:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	440	1E-02	na
USGS electronic	6436180	WWC	Site	10/9/1990	3:15:00 PM	Gaging Station	DISSOLVED	Silver	0.0005	480	1E-02	na
USGS electronic	6436180	WWC	Site	8/26/1997	8:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	410	1E-02	na
SDDENR electronic	460123	WWC	Site	1/13/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	637	7E-02	na
SDDENR electronic	460123	WWC	Site	2/18/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.005	480	1E-01	na
SDDENR electronic	460123	WWC	Site	11/24/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	490	7E-02	na
USGS electronic	6436198	WWC	Site	2/19/1993	10:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	690	1E-02	na
USGS electronic	6436198	WWC	Site	6/9/1998	12:35:00 PM	Gaging Station	DISSOLVED	Silver	0.0005	490	1E-02	na
USGS electronic	6436180	WWC	Site	4/21/1994	7:45:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	130	9E-02	na
USGS electronic	6436198	WWC	Site	7/15/1993	9:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	500	1E-02	na
USGS electronic	6436180	WWC	Site	10/22/1991	7:45:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	510	1E-02	na
EPA (1999) - Aquatic	BFR-R-10	BFRu	Ref	9/1/1999	--	Field	Dissolved	Silver	0.0005	678	1E-02	na
USGS electronic	6436180	WWC	Site	6/11/1991	8:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	240	3E-02	na
USGS electronic	6436180	WWC	Site	4/10/1991	12:45:00 PM	Gaging Station	DISSOLVED	Silver	0.0005	360	2E-02	na
USGS electronic	6436198	WWC	Site	8/19/1993	10:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	630	1E-02	na
USGS electronic	6436180	WWC	Site	5/10/1993	10:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	160	6E-02	na
USGS electronic	6436180	WWC	Site	8/30/1995	8:01:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	410	1E-02	na
USGS electronic	6436180	WWC	Site	6/9/1998	9:05:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	380	1E-02	na
USGS electronic	6436180	WWC	Site	7/19/1994	9:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	450	1E-02	na
USGS electronic	6436180	WWC	Site	8/15/1990	9:00:00 AM	Gaging Station	DISSOLVED	Silver	0.001	440	3E-02	na
USGS electronic	6436198	WWC	Site	10/9/1990	11:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	540	1E-02	na
USGS electronic	6436198	WWC	Site	1/8/1997	10:20:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	590	1E-02	na
SDDENR electronic	460123	WWC	Site	7/21/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	468	7E-02	na
USGS electronic	6436198	WWC	Site	5/8/1991	10:45:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	430	1E-02	na
USGS electronic	6436180	WWC	Site	8/18/1993	10:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	490	1E-02	na
USGS electronic	6436180	WWC	Site	9/2/1992	11:45:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	510	1E-02	na
USGS electronic	6436198	WWC	Site	11/26/1991	9:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	600	1E-02	na
USGS electronic	6436180	WWC	Site	12/22/1997	10:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	480	1E-02	na
SDDENR electronic	460686	WWC	Site	7/21/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	254	1E-01	na
USGS electronic	6436180	WWC	Site	2/14/1994	10:10:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	390	1E-02	na
SDDENR electronic	460682	WWC	Site	3/24/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.005	592	1E-01	na
USGS electronic	6436198	WWC	Site	9/11/1991	8:15:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	630	1E-02	na
SDDENR electronic	460682	WWC	Site	6/25/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	650	7E-02	na
SDDENR electronic	460686	WWC	Site	4/21/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.005	194	5E-01	na
USGS electronic	6436198	WWC	Site	3/16/1994	9:45:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	380	1E-02	na
USGS electronic	6436198	WWC	Site	4/29/1998	10:10:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	340	2E-02	na
SDDENR electronic	460686	WWC	Site	10/27/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.005	257	3E-01	na
SDDENR electronic	460686	WWC	Site	1/13/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	257	1E-01	na
USGS electronic	6436180	WWC	Site	11/8/1990	10:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	500	1E-02	na
USGS electronic	6436180	WWC	Site	3/17/1993	9:45:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	530	1E-02	na
USGS electronic	6436180	WWC	Site	7/11/1991	9:45:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	350	2E-02	na
USGS electronic	6436198	WWC	Site	2/12/1990	9:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	520	1E-02	na
USGS electronic	6436198	WWC	Site	7/10/1991	1:00:00 PM	Gaging Station	DISSOLVED	Silver	0.0005	480	1E-02	na

**APPENDIX E**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Aq SW COPCs	Adj Conc (mg/L)	Hardness (mg/L)	HQacute	HQchronic
SDDENR electronic	460682	WWC	Site	10/28/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.005	779	1E-01	na
EPA (1999) - Aquatic	WWC-05	WWC	Site	9/1/1999	--	Field	Dissolved	Silver	0.0005	496	1E-02	na
EPA (1999) - Aquatic	WWC-09	WWC	Site	9/1/1999	--	Extra (collocated with fish sample)	Dissolved	Silver	0.0025	681	7E-02	na
USGS electronic	6436198	WWC	Site	8/26/1997	12:30:00 PM	Gaging Station	DISSOLVED	Silver	0.0005	560	1E-02	na
EPA (1999) - Aquatic	WWC-02	WWC	Site	9/1/1999	--	Field	Dissolved	Silver	0.0012	233	8E-02	na
SDDENR electronic	460682	WWC	Site	8/18/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	559	7E-02	na
USGS electronic	6436198	WWC	Site	12/23/1997	9:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	750	1E-02	na
USGS electronic	6436198	WWC	Site	6/21/1994	9:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	570	1E-02	na
SDDENR electronic	460682	WWC	Site	2/18/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.005	630	1E-01	na
USGS electronic	6436198	WWC	Site	8/16/1990	11:00:00 AM	Gaging Station	DISSOLVED	Silver	0.001	570	3E-02	na
USGS electronic	6436180	WWC	Site	12/20/1994	9:10:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	500	1E-02	na
USGS electronic	6436180	WWC	Site	5/9/1991	8:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	330	2E-02	na
USGS electronic	6436198	WWC	Site	8/30/1995	12:15:00 PM	Gaging Station	DISSOLVED	Silver	0.0005	740	1E-02	na
USGS electronic	6436198	WWC	Site	5/8/1997	9:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	230	3E-02	na
USGS electronic	6436180	WWC	Site	4/28/1992	12:30:00 PM	Gaging Station	DISSOLVED	Silver	0.001	270	5E-02	na
USGS electronic	6436180	WWC	Site	4/14/1993	9:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	260	3E-02	na
USGS electronic	6436198	WWC	Site	1/17/1990	10:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	580	1E-02	na
USGS electronic	6436198	WWC	Site	8/18/1994	9:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	640	1E-02	na
EPA (1999) - Aquatic	WWC-08	WWC	Site	9/1/1999	--	Duplicate	Dissolved	Silver	0.0005	606	1E-02	na
USGS electronic	6436198	WWC	Site	7/19/1990	9:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	490	1E-02	na
USGS electronic	6436198	WWC	Site	5/30/1990	10:45:00 AM	Gaging Station	DISSOLVED	Silver	0.002	400	5E-02	na
USGS electronic	6436198	WWC	Site	1/15/1992	1:30:00 PM	Gaging Station	DISSOLVED	Silver	0.0005	780	1E-02	na
USGS electronic	6436198	WWC	Site	9/1/1994	10:15:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	570	1E-02	na
USGS electronic	6436180	WWC	Site	9/7/1994	9:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	510	1E-02	na
USGS electronic	6436180	WWC	Site	9/9/1993	7:45:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	490	1E-02	na
SDDENR electronic	460682	WWC	Site	11/24/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	675	7E-02	na
USGS electronic	6436180	WWC	Site	3/11/1992	11:15:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	420	1E-02	na
USGS electronic	6436180	WWC	Site	4/26/1990	12:15:00 PM	Gaging Station	DISSOLVED	Silver	0.0005	240	3E-02	na
USGS electronic	6436198	WWC	Site	12/21/1994	9:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	630	1E-02	na
USGS electronic	6436198	WWC	Site	6/21/1990	12:15:00 PM	Gaging Station	DISSOLVED	Silver	0.0005	460	1E-02	na
USGS electronic	6436180	WWC	Site	10/23/1996	9:10:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	490	1E-02	na
USGS electronic	6436180	WWC	Site	9/1/1994	8:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	460	1E-02	na
USGS electronic	6436180	WWC	Site	5/31/1990	9:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	300	2E-02	na
USGS electronic	6436198	WWC	Site	4/23/1990	9:30:00 AM	Gaging Station	DISSOLVED	Silver	0.002	330	7E-02	na
USGS electronic	6436198	WWC	Site	5/9/1995	8:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	280	2E-02	na
USGS electronic	6436198	WWC	Site	8/14/1991	8:45:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	590	1E-02	na
USGS electronic	6436198	WWC	Site	10/21/1991	10:45:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	620	1E-02	na
USGS electronic	6436180	WWC	Site	2/12/1992	10:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	540	1E-02	na
USGS electronic	6436198	WWC	Site	5/24/1995	12:00:00 PM	Gaging Station	DISSOLVED	Silver	0.0005	530	1E-02	na
USGS electronic	6436180	WWC	Site	12/13/1990	9:45:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	500	1E-02	na
USGS electronic	6436198	WWC	Site	6/5/1991	12:00:00 PM	Gaging Station	DISSOLVED	Silver	0.0005	320	2E-02	na
USGS electronic	6436198	WWC	Site	4/15/1993	9:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	380	1E-02	na
SDDENR electronic	460122	WWC	Site	2/18/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.005	538	1E-01	na
SDDENR electronic	460122	WWC	Site	3/24/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.005	486	1E-01	na
SDDENR electronic	460122	WWC	Site	5/27/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	301	1E-01	na
USGS electronic	6436198	WWC	Site	5/6/1993	3:50:00 PM	Gaging Station	DISSOLVED	Silver	0.0005	290	2E-02	na
SDDENR electronic	460684	WWC	Site	6/25/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	408	7E-02	na
USGS electronic	6436180	WWC	Site	5/8/1996	8:40:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	190	5E-02	na
USGS electronic	6436198	WWC	Site	12/12/1990	11:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	590	1E-02	na
SDDENR electronic	460122	WWC	Site	1/13/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	673	7E-02	na
USGS electronic	6436198	WWC	Site	10/14/1992	8:45:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	570	1E-02	na
EPA (1999) - Aquatic	SPC-R-12	OTHER	Ref	9/1/1999	--	Field	Dissolved	Silver	0.0013	292	6E-02	na
USGS electronic	6436180	WWC	Site	2/12/1990	1:00:00 PM	Gaging Station	DISSOLVED	Silver	0.001	450	3E-02	na
USGS electronic	6436180	WWC	Site	3/29/1990	12:30:00 PM	Gaging Station	DISSOLVED	Silver	0.0005	380	1E-02	na
EPA (1999) - Aquatic	WWC-03	WWC	Site	9/1/1999	--	Field	Dissolved	Silver	0.0005	499	1E-02	na
SDDENR electronic	460682	WWC	Site	12/16/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	555	7E-02	na
SDDENR electronic	460684	WWC	Site	5/27/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	291	1E-01	na
USGS electronic	6436180	WWC	Site	11/16/1992	10:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	560	1E-02	na
SDDENR electronic	460122	WWC	Site	7/21/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	480	7E-02	na
USGS electronic	6436198	WWC	Site	6/12/1992	9:15:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	460	1E-02	na
USGS electronic	6436198	WWC	Site	11/7/1990	12:15:00 PM	Gaging Station	DISSOLVED	Silver	0.0005	580	1E-02	na
USGS electronic	6436198	WWC	Site	4/10/1991	8:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	490	1E-02	na
SDDENR electronic	460122	WWC	Site	10/27/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.005	423	1E-01	na
USGS electronic	6436180	WWC	Site	1/16/1992	9:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	530	1E-02	na
SDDENR electronic	460122	WWC	Site	9/23/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.005	505	1E-01	na

**APPENDIX E**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Aq SW COPCs	Adj Conc (mg/L)	Hardness (mg/L)	HQacute	HQchronic
SDDENR electronic	460122	WWC	Site	6/25/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	447	7E-02	na
USGS electronic	6436198	WWC	Site	6/26/1996	8:10:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	640	1E-02	na
SDDENR electronic	460122	WWC	Site	8/18/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	449	7E-02	na
SDDENR electronic	460122	WWC	Site	11/24/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	517	7E-02	na
SDDENR electronic	460122	WWC	Site	12/16/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	580	7E-02	na
USGS electronic	6436198	WWC	Site	4/29/1992	9:15:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	340	2E-02	na
USGS electronic	6436180	WWC	Site	1/16/1990	2:30:00 PM	Gaging Station	DISSOLVED	Silver	0.001	470	3E-02	na
USGS electronic	6436198	WWC	Site	12/17/1991	9:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	680	1E-02	na
USGS electronic	6436198	WWC	Site	7/20/1994	9:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	530	1E-02	na
USGS electronic	6436180	WWC	Site	6/21/1990	6:00:00 PM	Gaging Station	DISSOLVED	Silver	0.001	400	3E-02	na
SDDENR electronic	460682	WWC	Site	5/12/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.005	434	1E-01	na
USGS electronic	6436180	WWC	Site	5/6/1993	1:15:00 PM	Gaging Station	DISSOLVED	Silver	0.001	170	1E-01	na
SDDENR electronic	460682	WWC	Site	1/14/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	917	7E-02	na
USGS electronic	6436180	WWC	Site	3/6/1991	12:30:00 PM	Gaging Station	DISSOLVED	Silver	0.0005	520	1E-02	na
USGS electronic	6436180	WWC	Site	12/27/1993	9:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	460	1E-02	na
EPA (1999) - Aquatic	WWC-08	WWC	Site	9/1/1999	--	Field	Dissolved	Silver	0.0018	597	5E-02	na
USGS electronic	6436180	WWC	Site	4/8/1992	2:15:00 PM	Gaging Station	DISSOLVED	Silver	0.0005	450	1E-02	na
USGS electronic	6436180	WWC	Site	6/11/1991	8:30:00 AM	Gaging Station	DISSOLVED	Lead	0.01	240	6E-02	3E+00
USGS electronic	6436198	WWC	Site	2/15/1994	9:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	550	1E-02	na
USGS electronic	6436180	WWC	Site	11/27/1991	9:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	460	1E-02	na
EPA (1999) - Aquatic	WWC-07	WWC	Site	9/1/1999	--	Field	Dissolved	Silver	0.0005	560	1E-02	na
USGS electronic	6436180	WWC	Site	8/11/1992	8:45:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	580	1E-02	na
USGS electronic	6436198	WWC	Site	8/12/1992	8:45:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	550	1E-02	na
USGS electronic	6436180	WWC	Site	12/9/1992	9:20:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	560	1E-02	na
USGS electronic	6436198	WWC	Site	5/10/1993	3:30:00 PM	Gaging Station	DISSOLVED	Silver	0.0005	250	3E-02	na
USGS electronic	6436180	WWC	Site	12/17/1991	1:45:00 PM	Gaging Station	DISSOLVED	Silver	0.0005	520	1E-02	na
USGS electronic	6436198	WWC	Site	3/29/1990	8:30:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	480	1E-02	na
USGS electronic	6436198	WWC	Site	9/3/1992	7:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	590	1E-02	na
SDDENR electronic	460682	WWC	Site	5/27/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.0025	526	7E-02	na
EPA (1999) - Aquatic	WWC-R-01 M	WWC	Ref	9/1/1999	--	Field	Dissolved	Silver	0.0014	240	9E-02	na
SDDENR electronic	460682	WWC	Site	4/20/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.005	382	1E-01	na
USGS electronic	6436180	WWC	Site	5/25/1996	10:00:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	210	4E-02	na
USGS electronic	6436198	WWC	Site	5/25/1994	10:20:00 AM	Gaging Station	DISSOLVED	Silver	0.0005	400	1E-02	na
SDDENR electronic	460682	WWC	Site	9/23/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.005	613	1E-01	na
SDDENR electronic	460122	WWC	Site	4/21/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Silver	0.005	240	3E-01	na
USGS electronic	6436180	WWC	Site	1/23/1991	2:30:00 PM	Gaging Station	DISSOLVED	Lead	0.01	460	4E-02	3E+00
USGS electronic	6436180	WWC	Site	6/11/1992	10:45:00 AM	Gaging Station	DISSOLVED	Lead	0.01	400	4E-02	3E+00
USGS electronic	6436198	WWC	Site	10/24/1996	9:00:00 AM	Gaging Station	DISSOLVED	Lead	0.005	670	2E-02	1E+00
USGS electronic	6436180	WWC	Site	11/8/1990	10:30:00 AM	Gaging Station	DISSOLVED	Lead	0.01	500	4E-02	3E+00
USGS electronic	6436198	WWC	Site	8/20/1996	12:15:00 PM	Gaging Station	DISSOLVED	Lead	0.005	670	2E-02	1E+00
SDDENR electronic	460123	WWC	Site	6/25/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	433	4E-03	3E-01
USGS electronic	6436180	WWC	Site	5/24/1995	8:30:00 AM	Gaging Station	DISSOLVED	Lead	0.005	270	3E-02	1E+00
USGS electronic	6436180	WWC	Site	1/6/1993	11:45:00 AM	Gaging Station	DISSOLVED	Lead	0.005	320	2E-02	1E+00
USGS electronic	6436198	WWC	Site	4/29/1992	9:15:00 AM	Gaging Station	DISSOLVED	Lead	0.005	340	2E-02	1E+00
SDDENR electronic	460123	WWC	Site	8/18/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	433	4E-03	3E-01
USGS electronic	6436198	WWC	Site	4/9/1992	9:45:00 AM	Gaging Station	DISSOLVED	Lead	0.01	540	4E-02	3E+00
USGS electronic	6436180	WWC	Site	10/23/1996	9:10:00 AM	Gaging Station	DISSOLVED	Lead	0.01	490	4E-02	3E+00
USGS electronic	6436180	WWC	Site	12/17/1991	1:45:00 PM	Gaging Station	DISSOLVED	Lead	0.01	520	4E-02	3E+00
SDDENR electronic	460123	WWC	Site	10/27/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	348	4E-03	3E-01
USGS electronic	6436180	WWC	Site	1/16/1992	9:00:00 AM	Gaging Station	DISSOLVED	Lead	0.005	530	2E-02	1E+00
USGS electronic	6436180	WWC	Site	9/7/1994	9:00:00 AM	Gaging Station	DISSOLVED	Lead	0.005	510	2E-02	1E+00
EPA (1999) - Aquatic	WWC-03	WWC	Site	9/1/1999	--	Field	Dissolved	Lead	0.001	499	4E-03	3E-01
USGS electronic	6436180	WWC	Site	6/9/1998	9:05:00 AM	Gaging Station	DISSOLVED	Lead	0.001	380	4E-03	3E-01
USGS electronic	6436180	WWC	Site	8/15/1991	8:15:00 AM	Gaging Station	DISSOLVED	Lead	0.01	510	4E-02	3E+00
SDDENR electronic	460123	WWC	Site	7/21/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.006	468	2E-02	2E+00
USGS electronic	6436198	WWC	Site	5/8/1996	1:30:00 PM	Gaging Station	DISSOLVED	Lead	0.005	360	2E-02	1E+00
USGS electronic	6436198	WWC	Site	2/11/1992	11:30:00 AM	Gaging Station	DISSOLVED	Lead	0.01	660	4E-02	3E+00
SDDENR electronic	460123	WWC	Site	2/18/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.006	480	2E-02	2E+00
SDDENR electronic	460123	WWC	Site	5/12/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	295	5E-03	3E-01
USGS electronic	6436198	WWC	Site	6/26/1996	8:10:00 AM	Gaging Station	DISSOLVED	Lead	0.005	640	2E-02	1E+00
USGS electronic	6436180	WWC	Site	2/18/1993	10:45:00 AM	Gaging Station	DISSOLVED	Lead	0.005	580	2E-02	1E+00
SDDENR electronic	460123	WWC	Site	11/24/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.005	490	2E-02	1E+00
USGS electronic	6436198	WWC	Site	5/25/1996	1:45:00 PM	Gaging Station	DISSOLVED	Lead	0.005	310	2E-02	1E+00
USGS electronic	6436198	WWC	Site	12/23/1997	9:00:00 AM	Gaging Station	DISSOLVED	Lead	0.0005	750	2E-03	1E-01
USGS electronic	6436180	WWC	Site	7/14/1992	11:00:00 AM	Gaging Station	DISSOLVED	Lead	0.005	440	2E-02	1E+00

**APPENDIX E**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Aq SW COPCs	Adj Conc (mg/L)	Hardness (mg/L)	HQacute	HQchronic
USGS electronic	6436180	WWC	Site	8/11/1992	8:45:00 AM	Gaging Station	DISSOLVED	Lead	0.005	580	2E-02	1E+00
USGS electronic	6436180	WWC	Site	1/7/1997	10:15:00 AM	Gaging Station	DISSOLVED	Lead	0.005	390	2E-02	1E+00
USGS electronic	6436198	WWC	Site	5/10/1993	3:30:00 PM	Gaging Station	DISSOLVED	Lead	0.005	250	3E-02	1E+00
SDDENR electronic	460123	WWC	Site	9/23/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	456	4E-03	3E-01
SDDENR electronic	460686	WWC	Site	7/21/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.002	254	1E-02	5E-01
SDDENR electronic	460682	WWC	Site	8/18/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	559	4E-03	3E-01
USGS electronic	6436198	WWC	Site	5/25/1994	10:20:00 AM	Gaging Station	DISSOLVED	Lead	0.005	400	2E-02	1E+00
USGS electronic	6436198	WWC	Site	4/29/1998	10:10:00 AM	Gaging Station	DISSOLVED	Lead	0.0005	340	2E-03	1E-01
SDDENR electronic	460682	WWC	Site	4/20/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	382	4E-03	3E-01
USGS electronic	6436198	WWC	Site	12/28/1993	9:30:00 AM	Gaging Station	DISSOLVED	Lead	0.02	730	8E-02	5E+00
SDDENR electronic	460122	WWC	Site	9/23/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	505	4E-03	3E-01
USGS electronic	6436198	WWC	Site	6/21/1994	9:30:00 AM	Gaging Station	DISSOLVED	Lead	0.005	570	2E-02	1E+00
USGS electronic	6436198	WWC	Site	9/3/1992	7:00:00 AM	Gaging Station	DISSOLVED	Lead	0.005	590	2E-02	1E+00
SDDENR electronic	460122	WWC	Site	10/27/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	423	4E-03	3E-01
EPA (1999) - Aquatic	WWC-04	WWC	Site	9/1/1999	--	Field	Dissolved	Lead	0.001	434	4E-03	3E-01
SDDENR electronic	460123	WWC	Site	3/24/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	408	4E-03	3E-01
SDDENR electronic	460123	WWC	Site	4/21/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	247	6E-03	3E-01
USGS electronic	6436198	WWC	Site	3/10/1992	9:15:00 AM	Gaging Station	DISSOLVED	Lead	0.005	530	2E-02	1E+00
USGS electronic	6436180	WWC	Site	9/12/1991	9:45:00 AM	Gaging Station	DISSOLVED	Lead	0.005	580	2E-02	1E+00
USGS electronic	6436198	WWC	Site	1/9/1996	11:30:00 AM	Gaging Station	DISSOLVED	Lead	0.005	710	2E-02	1E+00
EPA (1999) - Aquatic	BFR-11	BFRd	Site	9/1/1999	--	Field	Dissolved	Lead	0.001	661	4E-03	3E-01
SDDENR electronic	460682	WWC	Site	1/14/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.005	917	2E-02	1E+00
USGS electronic	6436180	WWC	Site	10/22/1991	7:45:00 AM	Gaging Station	DISSOLVED	Lead	0.01	510	4E-02	3E+00
SDDENR electronic	460682	WWC	Site	10/28/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	779	4E-03	3E-01
SDDENR electronic	460682	WWC	Site	9/23/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	613	4E-03	3E-01
SDDENR electronic	460123	WWC	Site	5/27/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	288	5E-03	3E-01
USGS electronic	6436198	WWC	Site	1/8/1997	10:20:00 AM	Gaging Station	DISSOLVED	Lead	0.005	590	2E-02	1E+00
USGS electronic	6436198	WWC	Site	1/8/1997	10:20:00 AM	Gaging Station	DISSOLVED	Copper	0.005	590	1E-01	3E-01
USGS electronic	6436180	WWC	Site	1/16/1992	9:00:00 AM	Gaging Station	DISSOLVED	Copper	0.005	530	1E-01	3E-01
USGS electronic	6436180	WWC	Site	12/17/1991	1:45:00 PM	Gaging Station	DISSOLVED	Copper	0.01	520	2E-01	6E-01
USGS electronic	6436198	WWC	Site	6/21/1990	12:15:00 PM	Gaging Station	DISSOLVED	Copper	0.005	460	1E-01	3E-01
USGS electronic	6436198	WWC	Site	5/30/1990	10:45:00 AM	Gaging Station	DISSOLVED	Copper	0.005	400	1E-01	3E-01
USGS electronic	6436180	WWC	Site	9/9/1993	7:45:00 AM	Gaging Station	DISSOLVED	Copper	0.005	490	1E-01	3E-01
USGS electronic	6436180	WWC	Site	3/15/1994	10:15:00 AM	Gaging Station	DISSOLVED	Copper	0.01	250	3E-01	6E-01
USGS electronic	6436198	WWC	Site	9/11/1990	9:00:00 AM	Gaging Station	DISSOLVED	Copper	0.005	560	1E-01	3E-01
USGS electronic	6436198	WWC	Site	8/26/1997	12:30:00 PM	Gaging Station	DISSOLVED	Copper	0.005	560	1E-01	3E-01
USGS electronic	6436180	WWC	Site	11/27/1991	9:00:00 AM	Gaging Station	DISSOLVED	Copper	0.01	460	2E-01	6E-01
USGS electronic	6436180	WWC	Site	6/25/1996	11:05:00 AM	Gaging Station	DISSOLVED	Lead	0.005	340	2E-02	1E+00
USGS electronic	6436198	WWC	Site	4/9/1992	9:45:00 AM	Gaging Station	DISSOLVED	Copper	0.005	540	1E-01	3E-01
USGS electronic	6436198	WWC	Site	4/21/1994	1:00:00 PM	Gaging Station	DISSOLVED	Silver	0.0005	180	5E-02	na
USGS electronic	6436198	WWC	Site	4/29/1992	9:15:00 AM	Gaging Station	DISSOLVED	Copper	0.005	340	1E-01	3E-01
USGS electronic	6436180	WWC	Site	8/20/1996	9:00:00 AM	Gaging Station	DISSOLVED	Copper	0.005	480	1E-01	3E-01
USGS electronic	6436198	WWC	Site	2/11/1992	11:30:00 AM	Gaging Station	DISSOLVED	Copper	0.005	660	1E-01	3E-01
USGS electronic	6436198	WWC	Site	6/16/1993	9:15:00 AM	Gaging Station	DISSOLVED	Copper	0.005	310	1E-01	3E-01
USGS electronic	6436198	WWC	Site	3/10/1992	9:15:00 AM	Gaging Station	DISSOLVED	Copper	0.005	530	1E-01	3E-01
USGS electronic	6436198	WWC	Site	12/23/1997	9:00:00 AM	Gaging Station	DISSOLVED	Copper	0.00218	750	4E-02	1E-01
EPA (1999) - Aquatic	WWC-04	WWC	Site	9/1/1999	--	Field	Dissolved	Copper	0.0054	434	1E-01	3E-01
USGS electronic	6436180	WWC	Site	12/27/1993	9:00:00 AM	Gaging Station	DISSOLVED	Copper	0.005	460	1E-01	3E-01
USGS electronic	6436180	WWC	Site	8/11/1992	8:45:00 AM	Gaging Station	DISSOLVED	Copper	0.005	580	1E-01	3E-01
USGS electronic	6436180	WWC	Site	4/14/1993	9:30:00 AM	Gaging Station	DISSOLVED	Copper	0.01	260	3E-01	6E-01
EPA (1999) - Aquatic	BFR-R-10	BFRu	Ref	9/1/1999	--	Field	Dissolved	Copper	0.0005	678	1E-02	3E-02
USGS electronic	6436198	WWC	Site	3/29/1990	8:30:00 AM	Gaging Station	DISSOLVED	Copper	0.005	480	1E-01	3E-01
USGS electronic	6436180	WWC	Site	1/7/1997	10:15:00 AM	Gaging Station	DISSOLVED	Copper	0.005	390	1E-01	3E-01
USGS electronic	6436198	WWC	Site	8/20/1996	12:15:00 PM	Gaging Station	DISSOLVED	Copper	0.005	670	1E-01	3E-01
USGS electronic	6436180	WWC	Site	2/18/1993	10:45:00 AM	Gaging Station	DISSOLVED	Copper	0.01	580	2E-01	6E-01
USGS electronic	6436198	WWC	Site	8/12/1992	8:45:00 AM	Gaging Station	DISSOLVED	Lead	0.005	550	2E-02	1E+00
USGS electronic	6436198	WWC	Site	5/25/1996	1:45:00 PM	Gaging Station	DISSOLVED	Copper	0.005	310	1E-01	3E-01
USGS electronic	6436198	WWC	Site	1/17/1990	10:00:00 AM	Gaging Station	DISSOLVED	Copper	0.005	580	1E-01	3E-01
USGS electronic	6436180	WWC	Site	2/14/1994	10:10:00 AM	Gaging Station	DISSOLVED	Copper	0.005	390	1E-01	3E-01
USGS electronic	6436198	WWC	Site	6/9/1998	12:35:00 PM	Gaging Station	DISSOLVED	Copper	0.00327	490	7E-02	2E-01
USGS electronic	6436180	WWC	Site	5/8/1996	8:40:00 AM	Gaging Station	DISSOLVED	Copper	0.005	190	2E-01	3E-01
USGS electronic	6436198	WWC	Site	2/12/1990	9:00:00 AM	Gaging Station	DISSOLVED	Copper	0.005	520	1E-01	3E-01
USGS electronic	6436198	WWC	Site	5/8/1997	9:00:00 AM	Gaging Station	DISSOLVED	Copper	0.005	230	2E-01	3E-01
USGS electronic	6436180	WWC	Site	2/12/1992	10:30:00 AM	Gaging Station	DISSOLVED	Lead	0.005	540	2E-02	1E+00
USGS electronic	6436180	WWC	Site	12/9/1992	9:20:00 AM	Gaging Station	DISSOLVED	Lead	0.01	560	4E-02	3E+00

**APPENDIX E**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Aq SW COPCs	Adj Conc (mg/L)	Hardness (mg/L)	HQacute	HQchronic
USGS electronic	6436198	WWC	Site	5/8/1997	9:00:00 AM	Gaging Station	DISSOLVED	Lead	0.005	230	3E-02	1E+00
USGS electronic	6436198	WWC	Site	8/30/1995	12:15:00 PM	Gaging Station	DISSOLVED	Lead	0.005	740	2E-02	1E+00
SDDENR electronic	460682	WWC	Site	5/12/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	434	4E-03	3E-01
EPA (1999) - Aquatic	WWC-09	WWC	Site	9/1/1999	--	Extra (collocated with fish sample)	Dissolved	Copper	0.003	681	6E-02	2E-01
EPA (1999) - Aquatic	WWC-09	WWC	Site	9/1/1999	--	Duplicate	Dissolved	Copper	0.003	694	6E-02	2E-01
USGS electronic	6436198	WWC	Site	10/24/1996	9:00:00 AM	Gaging Station	DISSOLVED	Copper	0.005	670	1E-01	3E-01
USGS electronic	6436198	WWC	Site	4/23/1990	9:30:00 AM	Gaging Station	DISSOLVED	Copper	0.005	330	1E-01	3E-01
USGS electronic	6436198	WWC	Site	1/7/1993	11:00:00 AM	Gaging Station	DISSOLVED	Copper	0.005	510	1E-01	3E-01
USGS electronic	6436198	WWC	Site	6/26/1996	8:10:00 AM	Gaging Station	DISSOLVED	Copper	0.005	640	1E-01	3E-01
USGS electronic	6436198	WWC	Site	7/19/1990	9:30:00 AM	Gaging Station	DISSOLVED	Copper	0.005	490	1E-01	3E-01
USGS electronic	6436198	WWC	Site	4/29/1998	10:10:00 AM	Gaging Station	DISSOLVED	Copper	0.00242	340	6E-02	1E-01
USGS electronic	6436198	WWC	Site	1/9/1996	11:30:00 AM	Gaging Station	DISSOLVED	Copper	0.005	710	1E-01	3E-01
USGS electronic	6436180	WWC	Site	10/22/1991	7:45:00 AM	Gaging Station	DISSOLVED	Copper	0.01	510	2E-01	6E-01
USGS electronic	6436180	WWC	Site	1/8/1996	12:30:00 PM	Gaging Station	DISSOLVED	Copper	0.01	450	2E-01	6E-01
USGS electronic	6436198	WWC	Site	5/8/1996	1:30:00 PM	Gaging Station	DISSOLVED	Copper	0.005	360	1E-01	3E-01
USGS electronic	6436198	WWC	Site	6/12/1992	9:15:00 AM	Gaging Station	DISSOLVED	Lead	0.01	460	4E-02	3E+00
USGS electronic	6436198	WWC	Site	8/16/1990	11:00:00 AM	Gaging Station	DISSOLVED	Copper	0.005	570	1E-01	3E-01
USGS electronic	6436180	WWC	Site	6/20/1994	9:45:00 AM	Gaging Station	DISSOLVED	Lead	0.01	430	4E-02	3E+00
USGS electronic	6436198	WWC	Site	2/15/1994	9:00:00 AM	Gaging Station	DISSOLVED	Lead	0.005	550	2E-02	1E+00
SDDENR electronic	460684	WWC	Site	9/23/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	431	4E-03	3E-01
SDDENR electronic	460684	WWC	Site	8/18/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	389	4E-03	3E-01
USGS electronic	6436198	WWC	Site	3/6/1991	8:30:00 AM	Gaging Station	DISSOLVED	Lead	0.005	450	2E-02	1E+00
USGS electronic	6436180	WWC	Site	5/7/1997	10:15:00 AM	Gaging Station	DISSOLVED	Lead	0.01	150	1E-01	3E+00
USGS electronic	6436180	WWC	Site	3/29/1990	12:30:00 PM	Gaging Station	DISSOLVED	Lead	0.01	380	4E-02	3E+00
SDDENR electronic	460684	WWC	Site	10/28/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	547	4E-03	3E-01
USGS electronic	6436180	WWC	Site	4/28/1998	10:30:00 AM	Gaging Station	DISSOLVED	Lead	0.0005	230	3E-03	1E-01
SDDENR electronic	460684	WWC	Site	3/24/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	366	4E-03	3E-01
USGS electronic	6436198	WWC	Site	4/23/1990	9:30:00 AM	Gaging Station	DISSOLVED	Lead	0.005	330	2E-02	1E+00
USGS electronic	6436180	WWC	Site	12/27/1993	9:00:00 AM	Gaging Station	DISSOLVED	Lead	0.005	460	2E-02	1E+00
SDDENR electronic	460684	WWC	Site	2/18/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.0025	393	1E-02	6E-01
USGS electronic	6436180	WWC	Site	6/15/1993	9:30:00 AM	Gaging Station	DISSOLVED	Lead	0.01	260	6E-02	3E+00
USGS electronic	6436198	WWC	Site	5/30/1990	10:45:00 AM	Gaging Station	DISSOLVED	Lead	0.005	400	2E-02	1E+00
SDDENR electronic	460684	WWC	Site	11/24/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.005	451	2E-02	1E+00
USGS electronic	6436180	WWC	Site	5/9/1991	8:30:00 AM	Gaging Station	DISSOLVED	Lead	0.01	330	4E-02	3E+00
USGS electronic	6436180	WWC	Site	12/22/1997	10:00:00 AM	Gaging Station	DISSOLVED	Lead	0.0005	480	2E-03	1E-01
USGS electronic	6436198	WWC	Site	2/12/1990	9:00:00 AM	Gaging Station	DISSOLVED	Lead	0.005	520	2E-02	1E+00
USGS electronic	6436180	WWC	Site	9/11/1990	2:30:00 PM	Gaging Station	DISSOLVED	Lead	0.01	480	4E-02	3E+00
USGS electronic	6436180	WWC	Site	8/30/1995	8:01:00 AM	Gaging Station	DISSOLVED	Lead	0.005	410	2E-02	1E+00
USGS electronic	6436180	WWC	Site	6/21/1990	6:00:00 PM	Gaging Station	DISSOLVED	Lead	0.01	400	4E-02	3E+00
USGS electronic	6436180	WWC	Site	7/20/1990	10:45:00 AM	Gaging Station	DISSOLVED	Lead	0.01	400	4E-02	3E+00
USGS electronic	6436180	WWC	Site	2/12/1990	1:00:00 PM	Gaging Station	DISSOLVED	Lead	0.01	450	4E-02	3E+00
EPA (1999) - Aquatic	WWC-08	WWC	Site	9/1/1999	--	Field	Dissolved	Lead	0.001	597	4E-03	3E-01
USGS electronic	6436180	WWC	Site	1/16/1990	2:30:00 PM	Gaging Station	DISSOLVED	Lead	0.01	470	4E-02	3E+00
USGS electronic	6436180	WWC	Site	7/11/1991	9:45:00 AM	Gaging Station	DISSOLVED	Lead	0.01	350	4E-02	3E+00
SDDENR electronic	460685	WWC	Site	1/13/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.005	492	2E-02	1E+00
SDDENR electronic	460685	WWC	Site	7/21/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.007	430	3E-02	2E+00
EPA (1999) - Aquatic	WWC-08	WWC	Site	9/1/1999	--	Duplicate	Dissolved	Lead	0.001	606	4E-03	3E-01
USGS electronic	6436198	WWC	Site	11/26/1991	9:00:00 AM	Gaging Station	DISSOLVED	Lead	0.005	600	2E-02	1E+00
USGS electronic	6436198	WWC	Site	11/7/1990	12:15:00 PM	Gaging Station	DISSOLVED	Lead	0.005	580	2E-02	1E+00
USGS electronic	6436180	WWC	Site	7/19/1994	9:00:00 AM	Gaging Station	DISSOLVED	Lead	0.01	450	4E-02	3E+00
USGS electronic	6436180	WWC	Site	10/9/1990	3:15:00 PM	Gaging Station	DISSOLVED	Lead	0.01	480	4E-02	3E+00
USGS electronic	6436180	WWC	Site	9/1/1994	8:00:00 AM	Gaging Station	DISSOLVED	Lead	0.01	460	4E-02	3E+00
USGS electronic	6436198	WWC	Site	9/11/1990	9:00:00 AM	Gaging Station	DISSOLVED	Lead	0.005	560	2E-02	1E+00
USGS electronic	6436198	WWC	Site	7/10/1991	1:00:00 PM	Gaging Station	DISSOLVED	Lead	0.005	480	2E-02	1E+00
USGS electronic	6436180	WWC	Site	4/10/1991	12:45:00 PM	Gaging Station	DISSOLVED	Lead	0.01	360	4E-02	3E+00
EPA (1999) - Aquatic	WWC-09	WWC	Site	9/1/1999	--	Duplicate	Dissolved	Lead	0.0005	694	2E-03	1E-01
USGS electronic	6436198	WWC	Site	10/9/1990	11:30:00 AM	Gaging Station	DISSOLVED	Lead	0.005	540	2E-02	1E+00
SDDENR electronic	460122	WWC	Site	12/16/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.005	580	2E-02	1E+00
SDDENR electronic	460684	WWC	Site	1/14/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.005	606	2E-02	1E+00
SDDENR electronic	460122	WWC	Site	2/18/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.0025	538	1E-02	6E-01
USGS electronic	6436180	WWC	Site	3/17/1993	9:45:00 AM	Gaging Station	DISSOLVED	Lead	0.005	530	2E-02	1E+00
USGS electronic	6436198	WWC	Site	12/17/1991	9:00:00 AM	Gaging Station	DISSOLVED	Lead	0.005	680	2E-02	1E+00
USGS electronic	6436180	WWC	Site	5/8/1996	8:40:00 AM	Gaging Station	DISSOLVED	Lead	0.005	190	4E-02	1E+00
SDDENR electronic	460684	WWC	Site	5/27/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	291	5E-03	3E-01
USGS electronic	6436198	WWC	Site	7/19/1990	9:30:00 AM	Gaging Station	DISSOLVED	Lead	0.005	490	2E-02	1E+00

**APPENDIX E**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Aq SW COPCs	Adj Conc (mg/L)	Hardness (mg/L)	HQacute	HQchronic
USGS electronic	6436198	WWC	Site	6/21/1990	12:15:00 PM	Gaging Station	DISSOLVED	Lead	0.005	460	2E-02	1E+00
USGS electronic	6436198	WWC	Site	3/29/1990	8:30:00 AM	Gaging Station	DISSOLVED	Lead	0.005	480	2E-02	1E+00
USGS electronic	6436198	WWC	Site	4/10/1991	8:30:00 AM	Gaging Station	DISSOLVED	Lead	0.005	490	2E-02	1E+00
SDDENR electronic	460684	WWC	Site	4/20/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	270	5E-03	3E-01
USGS electronic	6436198	WWC	Site	1/23/1991	8:45:00 AM	Gaging Station	DISSOLVED	Lead	0.005	680	2E-02	1E+00
USGS electronic	6436180	WWC	Site	8/18/1993	10:30:00 AM	Gaging Station	DISSOLVED	Lead	0.005	490	2E-02	1E+00
SDDENR electronic	460684	WWC	Site	5/12/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	281	5E-03	3E-01
USGS electronic	6436198	WWC	Site	10/21/1991	10:45:00 AM	Gaging Station	DISSOLVED	Lead	0.005	620	2E-02	1E+00
USGS electronic	6436180	WWC	Site	5/10/1993	10:30:00 AM	Gaging Station	DISSOLVED	Lead	0.01	160	9E-02	3E+00
USGS electronic	6436180	WWC	Site	4/26/1990	12:15:00 PM	Gaging Station	DISSOLVED	Lead	0.01	240	6E-02	3E+00
SDDENR electronic	460122	WWC	Site	11/24/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.005	517	2E-02	1E+00
EPA (1999) - Aquatic	WWC-09	WWC	Site	9/1/1999	--	Field	Dissolved	Lead	0.0005	704	2E-03	1E-01
EPA (1999) - Aquatic	WWC-07	WWC	Site	9/1/1999	--	Field	Dissolved	Lead	0.001	560	4E-03	3E-01
SDDENR electronic	460684	WWC	Site	6/25/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	408	4E-03	3E-01
USGS electronic	6436198	WWC	Site	8/26/1997	12:30:00 PM	Gaging Station	DISSOLVED	Lead	0.005	560	2E-02	1E+00
USGS electronic	6436198	WWC	Site	1/7/1993	11:00:00 AM	Gaging Station	DISSOLVED	Lead	0.005	510	2E-02	1E+00
USGS electronic	6436198	WWC	Site	12/9/1992	12:30:00 PM	Gaging Station	DISSOLVED	Lead	0.005	640	2E-02	1E+00
USGS electronic	6436198	WWC	Site	12/21/1994	9:00:00 AM	Gaging Station	DISSOLVED	Lead	0.03	630	1E-01	8E+00
USGS electronic	6436198	WWC	Site	6/16/1993	9:15:00 AM	Gaging Station	DISSOLVED	Lead	0.005	310	2E-02	1E+00
EPA (1999) - Aquatic	WWC-02	WWC	Site	9/1/1999	--	Field	Dissolved	Lead	0.001	233	6E-03	3E-01
SDDENR electronic	460682	WWC	Site	5/27/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	526	4E-03	3E-01
USGS electronic	6436180	WWC	Site	3/6/1991	12:30:00 PM	Gaging Station	DISSOLVED	Lead	0.01	520	4E-02	3E+00
USGS electronic	6436198	WWC	Site	11/17/1992	11:15:00 AM	Gaging Station	DISSOLVED	Lead	0.005	590	2E-02	1E+00
USGS electronic	6436198	WWC	Site	5/9/1995	8:30:00 AM	Gaging Station	DISSOLVED	Lead	0.04	280	2E-01	1E+01
USGS electronic	6436180	WWC	Site	5/8/1995	6:45:00 PM	Gaging Station	DISSOLVED	Lead	0.01	110	1E-01	4E+00
USGS electronic	6436198	WWC	Site	5/24/1995	12:00:00 PM	Gaging Station	DISSOLVED	Lead	0.005	530	2E-02	1E+00
USGS electronic	6436198	WWC	Site	1/17/1990	10:00:00 AM	Gaging Station	DISSOLVED	Lead	0.005	580	2E-02	1E+00
USGS electronic	6436198	WWC	Site	2/19/1993	10:00:00 AM	Gaging Station	DISSOLVED	Lead	0.01	690	4E-02	3E+00
SDDENR electronic	460682	WWC	Site	11/24/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.005	675	2E-02	1E+00
USGS electronic	6436198	WWC	Site	9/9/1993	10:30:00 AM	Gaging Station	DISSOLVED	Lead	0.005	630	2E-02	1E+00
SDDENR electronic	460682	WWC	Site	3/24/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	592	4E-03	3E-01
USGS electronic	6436198	WWC	Site	7/15/1993	9:30:00 AM	Gaging Station	DISSOLVED	Lead	0.005	500	2E-02	1E+00
USGS electronic	6436198	WWC	Site	6/9/1998	12:35:00 PM	Gaging Station	DISSOLVED	Lead	0.0005	490	2E-03	1E-01
SDDENR electronic	460682	WWC	Site	12/16/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.005	555	2E-02	1E+00
SDDENR electronic	460682	WWC	Site	2/18/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.0025	630	1E-02	6E-01
USGS electronic	6436180	WWC	Site	10/13/1992	11:15:00 AM	Gaging Station	DISSOLVED	Lead	0.005	540	2E-02	1E+00
USGS electronic	6436198	WWC	Site	4/21/1994	1:00:00 PM	Gaging Station	DISSOLVED	Lead	0.005	180	4E-02	1E+00
SDDENR electronic	460686	WWC	Site	10/27/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	257	6E-03	3E-01
USGS electronic	6436180	WWC	Site	8/20/1996	9:00:00 AM	Gaging Station	DISSOLVED	Lead	0.005	480	2E-02	1E+00
EPA (1999) - Aquatic	BFR-R-10	BFRu	Ref	9/1/1999	--	Field	Dissolved	Lead	0.001	678	4E-03	3E-01
USGS electronic	6436180	WWC	Site	4/28/1992	12:30:00 PM	Gaging Station	DISSOLVED	Lead	0.01	270	5E-02	3E+00
USGS electronic	6436198	WWC	Site	3/16/1994	9:45:00 AM	Gaging Station	DISSOLVED	Lead	0.005	380	2E-02	1E+00
USGS electronic	6436180	WWC	Site	8/26/1997	8:30:00 AM	Gaging Station	DISSOLVED	Lead	0.01	410	4E-02	3E+00
USGS electronic	6436198	WWC	Site	8/19/1993	10:00:00 AM	Gaging Station	DISSOLVED	Lead	0.005	630	2E-02	1E+00
USGS electronic	6436198	WWC	Site	5/8/1991	10:45:00 AM	Gaging Station	DISSOLVED	Lead	0.005	430	2E-02	1E+00
USGS electronic	6436180	WWC	Site	12/13/1990	9:45:00 AM	Gaging Station	DISSOLVED	Lead	0.01	500	4E-02	3E+00
USGS electronic	6436198	WWC	Site	9/1/1994	10:15:00 AM	Gaging Station	DISSOLVED	Lead	0.005	570	2E-02	1E+00
USGS electronic	6436180	WWC	Site	4/8/1992	2:15:00 PM	Gaging Station	DISSOLVED	Lead	0.005	450	2E-02	1E+00
USGS electronic	6436198	WWC	Site	12/12/1990	11:30:00 AM	Gaging Station	DISSOLVED	Lead	0.005	590	2E-02	1E+00
USGS electronic	6436180	WWC	Site	11/16/1992	10:30:00 AM	Gaging Station	DISSOLVED	Lead	0.005	560	2E-02	1E+00
EPA (1999) - Aquatic	WWC-09	WWC	Site	9/1/1999	--	Extra (collocated with fish sample)	Dissolved	Lead	0.0005	681	2E-03	1E-01
USGS electronic	6436198	WWC	Site	3/18/1993	9:30:00 AM	Gaging Station	DISSOLVED	Lead	0.005	650	2E-02	1E+00
EPA (1999) - Aquatic	WWC-06	WWC	Site	9/1/1999	--	Field	Dissolved	Lead	0.001	537	4E-03	3E-01
USGS electronic	6436180	WWC	Site	5/24/1994	11:10:00 AM	Gaging Station	DISSOLVED	Lead	0.01	290	5E-02	3E+00
USGS electronic	6436180	WWC	Site	2/14/1994	10:10:00 AM	Gaging Station	DISSOLVED	Lead	0.01	390	4E-02	3E+00
USGS electronic	6436180	WWC	Site	5/31/1990	9:30:00 AM	Gaging Station	DISSOLVED	Lead	0.01	300	5E-02	3E+00
USGS electronic	6436180	WWC	Site	9/9/1993	7:45:00 AM	Gaging Station	DISSOLVED	Lead	0.005	490	2E-02	1E+00
USGS electronic	6436180	WWC	Site	1/6/1993	11:45:00 AM	Gaging Station	DISSOLVED	Copper	0.005	320	1E-01	3E-01
USGS electronic	6436180	WWC	Site	5/6/1993	1:15:00 PM	Gaging Station	DISSOLVED	Lead	0.01	170	9E-02	3E+00
SDDENR electronic	460686	WWC	Site	1/13/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.005	257	3E-02	1E+00
EPA (1999) - Aquatic	WWC-R-01 M	WWC	Ref	9/1/1999	--	Field	Dissolved	Lead	0.001	240	6E-03	3E-01
USGS electronic	6436198	WWC	Site	10/14/1992	8:45:00 AM	Gaging Station	DISSOLVED	Lead	0.005	570	2E-02	1E+00
USGS electronic	6436198	WWC	Site	5/6/1993	3:50:00 PM	Gaging Station	DISSOLVED	Lead	0.005	290	2E-02	1E+00
USGS electronic	6436198	WWC	Site	7/20/1994	9:00:00 AM	Gaging Station	DISSOLVED	Lead	0.005	530	2E-02	1E+00
SDDENR electronic	460682	WWC	Site	6/25/1997	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	650	4E-03	3E-01

**APPENDIX E**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Aq SW COPCs	Adj Conc (mg/L)	Hardness (mg/L)	HQacute	HQchronic
EPA (1999) - Aquatic	SPC-R-12	OTHER	Ref	9/1/1999	–	Field	Dissolved	Lead	0.001	292	5E-03	3E-01
USGS electronic	6436198	WWC	Site	8/18/1994	9:00:00 AM	Gaging Station	DISSOLVED	Lead	0.005	640	2E-02	1E+00
USGS electronic	6436180	WWC	Site	3/11/1992	11:15:00 AM	Gaging Station	DISSOLVED	Lead	0.005	420	2E-02	1E+00
USGS electronic	6436198	WWC	Site	4/15/1993	9:00:00 AM	Gaging Station	DISSOLVED	Lead	0.01	380	4E-02	3E+00
USGS electronic	6436180	WWC	Site	11/27/1991	9:00:00 AM	Gaging Station	DISSOLVED	Lead	0.005	460	2E-02	1E+00
USGS electronic	6436180	WWC	Site	9/2/1992	11:45:00 AM	Gaging Station	DISSOLVED	Lead	0.01	510	4E-02	3E+00
USGS electronic	6436180	WWC	Site	12/20/1994	9:10:00 AM	Gaging Station	DISSOLVED	Lead	0.01	500	4E-02	3E+00
USGS electronic	6436198	WWC	Site	6/5/1991	12:00:00 PM	Gaging Station	DISSOLVED	Lead	0.005	320	2E-02	1E+00
SDDENR electronic	460686	WWC	Site	4/21/1998	12:00:00 AM	Water Quality Monitoring	Dissolved	Lead	0.001	194	8E-03	3E-01

**APPENDIX E**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Typ	Parameter	Adj Conc (ppm)	HQacute	HQchronic
SDDENR electronic	460123	WWC	Site	35234	1010	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460684	WWC	Site	36180	0.34375	Water Quality Monitoring Station	WAD	Cyanide	0.008	4E-01	2E+00
SDDENR electronic	460685	WWC	Site	35990	715	Water Quality Monitoring	WAD	Cyanide	0.01	5E-01	2E+00
SDDENR electronic	460123	WWC	Site	35544	1225	Water Quality Monitoring	WAD	Cyanide	0.08	4E+00	2E+01
SDDENR electronic	460123	WWC	Site	34808	830	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460684	WWC	Site	35927	1100	Water Quality Monitoring	WAD	Cyanide	0.019	9E-01	4E+00
SDDENR electronic	460684	WWC	Site	35905	835	Water Quality Monitoring	WAD	Cyanide	0.022	1E+00	4E+00
SDDENR electronic	460684	WWC	Site	35962	1120	Water Quality Monitoring	WAD	Cyanide	0.04	2E+00	8E+00
SDDENR electronic	460122	WWC	Site	34073	1430	Water Quality Monitoring	WAD	Cyanide	0.03	1E+00	6E+00
SDDENR electronic	460123	WWC	Site	34709	810	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460123	WWC	Site	34646	1110	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460123	WWC	Site	34988	1425	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460685	WWC	Site	36543	0.645833333	Water Quality Monitoring Station	WAD	Cyanide	0.066	3E+00	1E+01
SDDENR electronic	460684	WWC	Site	36895	0.368055556	Water Quality Monitoring Station	WAD	Cyanide	0.021	1E+00	4E+00
SDDENR electronic	460123	WWC	Site	34631	1210	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460123	WWC	Site	36591	0.5	Water Quality Monitoring Station	WAD	Cyanide	0.034	2E+00	7E+00
SDDENR electronic	460123	WWC	Site	35275	1430	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460123	WWC	Site	35297	925	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460123	WWC	Site	35325	1000	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460123	WWC	Site	34589	950	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460123	WWC	Site	35361	905	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460682	WWC	Site	35962	1435	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460684	WWC	Site	36279	0.361111111	Water Quality Monitoring Station	WAD	Cyanide	0.007	3E-01	1E+00
SDDENR electronic	460685	WWC	Site	35632	1425	Water Quality Monitoring	WAD	Cyanide	0.015	7E-01	3E+00
SDDENR electronic	460684	WWC	Site	36642	0.350694444	Water Quality Monitoring Station	WAD	Cyanide	0.0025	1E-01	5E-01
SDDENR electronic	460684	WWC	Site	35543	840	Water Quality Monitoring	WAD	Cyanide	0.06	3E+00	1E+01
SDDENR electronic	460684	WWC	Site	35758	1100	Water Quality Monitoring	WAD	Cyanide	0.026	1E+00	5E+00
SDDENR electronic	460684	WWC	Site	35844	1120	Water Quality Monitoring	WAD	Cyanide	0.029	1E+00	6E+00
SDDENR electronic	460684	WWC	Site	35780	1200	Water Quality Monitoring	WAD	Cyanide	0.031	1E+00	6E+00
SDDENR electronic	460684	WWC	Site	36025	1355	Water Quality Monitoring	WAD	Cyanide	0.016	7E-01	3E+00
SDDENR electronic	460684	WWC	Site	34332	1030	Water Quality Monitoring	WAD	Cyanide	0.014	6E-01	3E+00
SDDENR electronic	460685	WWC	Site	35185	1410	Water Quality Monitoring	WAD	Cyanide	0.02	9E-01	4E+00
SDDENR electronic	460684	WWC	Site	35353	825	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460123	WWC	Site	35045	955	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460123	WWC	Site	35906	1420	Water Quality Monitoring	WAD	Cyanide	0.016	7E-01	3E+00
SDDENR electronic	460123	WWC	Site	34969	950	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460122	WWC	Site	34562	950	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460123	WWC	Site	34898	825	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460122	WWC	Site	34417	1040	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460684	WWC	Site	35606	1135	Water Quality Monitoring	WAD	Cyanide	0.08	4E+00	2E+01
SDDENR electronic	460123	WWC	Site	34877	805	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460684	WWC	Site	36895	0.368055556	Water Quality Monitoring Station	WAD	Cyanide	0.021	1E+00	4E+00
SDDENR electronic	460123	WWC	Site	36894	0.625	Water Quality Monitoring Station	WAD	Cyanide	0.034	2E+00	7E+00
SDDENR electronic	460684	WWC	Site	36544	0.375	Water Quality Monitoring Station	WAD	Cyanide	0.042	2E+00	8E+00
SDDENR electronic	460123	WWC	Site	34822	1010	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460123	WWC	Site	36179	0.604166667	Water Quality Monitoring Station	WAD	Cyanide	0.043	2E+00	8E+00
SDDENR electronic	460684	WWC	Site	36213	0.5	Water Quality Monitoring Station	WAD	Cyanide	0.056	3E+00	1E+01
SDDENR electronic	460684	WWC	Site	36592	0.354166667	Water Quality Monitoring Station	WAD	Cyanide	0.012	5E-01	2E+00
SDDENR electronic	460123	WWC	Site	36543	0.621527778	Water Quality Monitoring Station	WAD	Cyanide	0.092	4E+00	2E+01
SDDENR electronic	460684	WWC	Site	36243	0.375	Water Quality Monitoring Station	WAD	Cyanide	0.029	1E+00	6E+00
SDDENR electronic	460123	WWC	Site	35927	1025	Water Quality Monitoring	WAD	Cyanide	0.018	8E-01	3E+00

**APPENDIX E**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Typ	Parameter	Adj Conc (ppm)	HQacute	HQchronic
SDDENR electronic	460122	WWC	Site	34752	1120	Water Quality Monitoring	WAD	Cyanide	0.016	7E-01	3E+00
SDDENR electronic	460123	WWC	Site	36641	0.614583333	Water Quality Monitoring Station	WAD	Cyanide	0.0025	1E-01	5E-01
SDDENR electronic	460685	WWC	Site	36894	0.642361111	Water Quality Monitoring Station	WAD	Cyanide	0.015	7E-01	3E+00
SDDENR electronic	460122	WWC	Site	35780	1040	Water Quality Monitoring	WAD	Cyanide	0.026	1E+00	5E+00
SDDENR electronic	460122	WWC	Site	35730	1355	Water Quality Monitoring	WAD	Cyanide	0.02	9E-01	4E+00
SDDENR electronic	460123	WWC	Site	36752	0.440972222	Water Quality Monitoring Station	WAD	Cyanide	0.017	8E-01	3E+00
SDDENR electronic	460685	WWC	Site	36081	0.645833333	Water Quality Monitoring Station	WAD	Cyanide	0.011	5E-01	2E+00
SDDENR electronic	460123	WWC	Site	36509	0.524305556	Water Quality Monitoring Station	WAD	Cyanide	0.019	9E-01	4E+00
SDDENR electronic	460685	WWC	Site	36458	0.354166667	Water Quality Monitoring Station	WAD	Cyanide	0.0025	1E-01	5E-01
SDDENR electronic	460123	WWC	Site	36565	0.479166667	Water Quality Monitoring Station	WAD	Cyanide	0.021	1E+00	4E+00
SDDENR electronic	460123	WWC	Site	36815	0.565972222	Water Quality Monitoring Station	WAD	Cyanide	0.012	5E-01	2E+00
SDDENR electronic	460123	WWC	Site	35381	835	Water Quality Monitoring	WAD	Cyanide	0.01	5E-01	2E+00
SDDENR electronic	460684	WWC	Site	36362	0.565972222	Water Quality Monitoring Station	WAD	Cyanide	0.021	1E+00	4E+00
SDDENR electronic	460684	WWC	Site	35731	1100	Water Quality Monitoring	WAD	Cyanide	0.022	1E+00	4E+00
SDDENR electronic	460123	WWC	Site	36481	0.503472222	Water Quality Monitoring Station	WAD	Cyanide	0.021	1E+00	4E+00
SDDENR electronic	460122	WWC	Site	35425	1110	Water Quality Monitoring	WAD	Cyanide	0.03	1E+00	6E+00
SDDENR electronic	460123	WWC	Site	36118	0.46875	Water Quality Monitoring Station	WAD	Cyanide	0.021	1E+00	4E+00
SDDENR electronic	460685	WWC	Site	36641	0.635416667	Water Quality Monitoring Station	WAD	Cyanide	0.0025	1E-01	5E-01
SDDENR electronic	460123	WWC	Site	36214	0.541666667	Water Quality Monitoring Station	WAD	Cyanide	0.076	3E+00	1E+01
SDDENR electronic	460122	WWC	Site	34988	1340	Water Quality Monitoring	WAD	Cyanide	0.012	5E-01	2E+00
SDDENR electronic	460122	WWC	Site	35632	1310	Water Quality Monitoring	WAD	Cyanide	0.012	5E-01	2E+00
SDDENR electronic	460122	WWC	Site	35660	950	Water Quality Monitoring	WAD	Cyanide	0.012	5E-01	2E+00
SDDENR electronic	460685	WWC	Site	35544	1245	Water Quality Monitoring	WAD	Cyanide	0.09	4E+00	2E+01
SDDENR electronic	460122	WWC	Site	34311	1120	Water Quality Monitoring	WAD	Cyanide	0.014	6E-01	3E+00
SDDENR electronic	460123	WWC	Site	36242	0.552083333	Water Quality Monitoring Station	WAD	Cyanide	0.019	9E-01	4E+00
SDDENR electronic	460122	WWC	Site	35080	940	Water Quality Monitoring	WAD	Cyanide	0.03	1E+00	6E+00
SDDENR electronic	460122	WWC	Site	35844	955	Water Quality Monitoring	WAD	Cyanide	0.038	2E+00	7E+00
SDDENR electronic	460122	WWC	Site	35471	1235	Water Quality Monitoring	WAD	Cyanide	0.037	2E+00	7E+00
SDDENR electronic	460685	WWC	Site	35808	840	Water Quality Monitoring	WAD	Cyanide	0.0025	1E-01	5E-01
SDDENR electronic	460123	WWC	Site	34939	1010	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460685	WWC	Site	35451	1530	Water Quality Monitoring	WAD	Cyanide	0.056	3E+00	1E+01
SDDENR electronic	460122	WWC	Site	35696	955	Water Quality Monitoring	WAD	Cyanide	0.036	2E+00	7E+00
SDDENR electronic	460122	WWC	Site	35451	1430	Water Quality Monitoring	WAD	Cyanide	0.034	2E+00	7E+00
SDDENR electronic	460123	WWC	Site	37229	0.534722222	Water Quality Monitoring Station	WAD	Cyanide	0.0025	1E-01	5E-01
SDDENR electronic	460122	WWC	Site	35150	1020	Water Quality Monitoring	WAD	Cyanide	0.04	2E+00	8E+00
SDDENR electronic	460122	WWC	Site	35808	940	Water Quality Monitoring	WAD	Cyanide	0.044	2E+00	8E+00
SDDENR electronic	460123	WWC	Site	34470	1015	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460684	WWC	Site	35184	830	Water Quality Monitoring	WAD	Cyanide	0.01	5E-01	2E+00
SDDENR electronic	460123	WWC	Site	36844	0.541666667	Water Quality Monitoring Station	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460684	WWC	Site	35381	1145	Water Quality Monitoring	WAD	Cyanide	0.01	5E-01	2E+00
SDDENR electronic	460685	WWC	Site	36361	0.642361111	Water Quality Monitoring Station	WAD	Cyanide	0.013	6E-01	3E+00
SDDENR electronic	460685	WWC	Site	35730	1450	Water Quality Monitoring	WAD	Cyanide	0.013	6E-01	3E+00
SDDENR electronic	460122	WWC	Site	35758	940	Water Quality Monitoring	WAD	Cyanide	0.029	1E+00	6E+00
SDDENR electronic	460684	WWC	Site	35809	1315	Water Quality Monitoring	WAD	Cyanide	0.098	4E+00	2E+01
SDDENR electronic	460123	WWC	Site	35201	1110	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460685	WWC	Site	36179	0.618055556	Water Quality Monitoring Station	WAD	Cyanide	0.037	2E+00	7E+00
SDDENR electronic	460123	WWC	Site	36025	1310	Water Quality Monitoring	WAD	Cyanide	0.03	1E+00	6E+00
SDDENR electronic	460122	WWC	Site	35507	930	Water Quality Monitoring	WAD	Cyanide	0.059	3E+00	1E+01
SDDENR electronic	460123	WWC	Site	35962	1040	Water Quality Monitoring	WAD	Cyanide	0.047	2E+00	9E+00
SDDENR electronic	460123	WWC	Site	35990	740	Water Quality Monitoring	WAD	Cyanide	0.012	5E-01	2E+00
SDDENR electronic	460684	WWC	Site	36306	0.524305556	Water Quality Monitoring Station	WAD	Cyanide	0.007	3E-01	1E+00

**APPENDIX E**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Typ	Parameter	Adj Conc (ppm)	HQacute	HQchronic
SDDENR electronic	460122	WWC	Site	34631	1135	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460122	WWC	Site	35381	855	Water Quality Monitoring	WAD	Cyanide	0.01	5E-01	2E+00
SDDENR electronic	460122	WWC	Site	34822	940	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460122	WWC	Site	34808	850	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460122	WWC	Site	35577	955	Water Quality Monitoring	WAD	Cyanide	0.0025	1E-01	5E-01
SDDENR electronic	460122	WWC	Site	34772	1205	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460122	WWC	Site	34709	840	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460684	WWC	Site	34452	1300	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460122	WWC	Site	34646	1035	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460122	WWC	Site	34969	925	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460122	WWC	Site	34589	920	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460122	WWC	Site	36591	0.447916667	Water Quality Monitoring Station	WAD	Cyanide	0.044	2E+00	8E+00
SDDENR electronic	460122	WWC	Site	34939	950	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460123	WWC	Site	35109	1205	Water Quality Monitoring	WAD	Cyanide	0.03	1E+00	6E+00
SDDENR electronic	460123	WWC	Site	34417	1005	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460123	WWC	Site	35758	1005	Water Quality Monitoring	WAD	Cyanide	0.0025	1E-01	5E-01
SDDENR electronic	460122	WWC	Site	34681	1230	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460122	WWC	Site	35234	945	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460122	WWC	Site	35606	845	Water Quality Monitoring	WAD	Cyanide	0.011	5E-01	2E+00
SDDENR electronic	460122	WWC	Site	36214	0.493055556	Water Quality Monitoring Station	WAD	Cyanide	0.051	2E+00	1E+01
SDDENR electronic	460122	WWC	Site	36894	0.482638889	Water Quality Monitoring Station	WAD	Cyanide	0.041	2E+00	8E+00
SDDENR electronic	460122	WWC	Site	36509	0.479166667	Water Quality Monitoring Station	WAD	Cyanide	0.017	8E-01	3E+00
SDDENR electronic	460122	WWC	Site	36242	0.479166667	Water Quality Monitoring Station	WAD	Cyanide	0.038	2E+00	7E+00
SDDENR electronic	460122	WWC	Site	34877	830	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460122	WWC	Site	34898	845	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460122	WWC	Site	35275	1325	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460122	WWC	Site	35361	920	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460123	WWC	Site	35011	1130	Water Quality Monitoring	WAD	Cyanide	0.013	6E-01	3E+00
SDDENR electronic	460123	WWC	Site	34772	1140	Water Quality Monitoring	WAD	Cyanide	0.013	6E-01	3E+00
SDDENR electronic	460122	WWC	Site	35201	1140	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460122	WWC	Site	35109	1140	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460122	WWC	Site	35045	930	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460122	WWC	Site	35011	1200	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460123	WWC	Site	35471	1330	Water Quality Monitoring	WAD	Cyanide	0.069	3E+00	1E+01
SDDENR electronic	460122	WWC	Site	35297	955	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460122	WWC	Site	34505	1000	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460123	WWC	Site	35577	1025	Water Quality Monitoring	WAD	Cyanide	0.0025	1E-01	5E-01
SDDENR electronic	460686	WWC	Site	35990	855	Water Quality Monitoring	WAD	Cyanide	0.0025	1E-01	5E-01
SDDENR electronic	460682	WWC	Site	36592	0.489583333	Water Quality Monitoring Station	WAD	Cyanide	0.008	4E-01	2E+00
SDDENR electronic	460682	WWC	Site	36362	0.354166667	Water Quality Monitoring Station	WAD	Cyanide	0.0025	1E-01	5E-01
SDDENR electronic	460682	WWC	Site	36243	0.555555556	Water Quality Monitoring Station	WAD	Cyanide	0.008	4E-01	2E+00
SDDENR electronic	460682	WWC	Site	36642	0.552083333	Water Quality Monitoring Station	WAD	Cyanide	0.0025	1E-01	5E-01
SDDENR electronic	460123	WWC	Site	35780	1105	Water Quality Monitoring	WAD	Cyanide	0.038	2E+00	7E+00
SDDENR electronic	460682	WWC	Site	36459	0.534722222	Water Quality Monitoring Station	WAD	Cyanide	0.0025	1E-01	5E-01
SDDENR electronic	460684	WWC	Site	36844	0.576388889	Water Quality Monitoring Station	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460682	WWC	Site	36060	0.652777778	Water Quality Monitoring Station	WAD	Cyanide	0.0025	1E-01	5E-01
SDDENR electronic	460684	WWC	Site	36424	0.34375	Water Quality Monitoring Station	WAD	Cyanide	0.032	1E+00	6E+00
SDDENR electronic	460122	WWC	Site	35962	1015	Water Quality Monitoring	WAD	Cyanide	0.037	2E+00	7E+00
SDDENR electronic	460122	WWC	Site	35927	1000	Water Quality Monitoring	WAD	Cyanide	0.02	9E-01	4E+00
SDDENR electronic	460122	WWC	Site	36025	1145	Water Quality Monitoring	WAD	Cyanide	0.017	8E-01	3E+00
SDDENR electronic	460122	WWC	Site	35990	820	Water Quality Monitoring	WAD	Cyanide	0.017	8E-01	3E+00

**APPENDIX E**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Typ	Parameter	Adj Conc (ppm)	HQacute	HQchronic
SDDENR electronic	460122	WWC	Site	35906	1355	Water Quality Monitoring	WAD	Cyanide	0.013	6E-01	3E+00
SDDENR electronic	460122	WWC	Site	35325	930	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460123	WWC	Site	35808	915	Water Quality Monitoring	WAD	Cyanide	0.028	1E+00	5E+00
SDDENR electronic	460122	WWC	Site	36361	0.465277778	Water Quality Monitoring Station	WAD	Cyanide	0.032	1E+00	6E+00
SDDENR electronic	460123	WWC	Site	35451	1515	Water Quality Monitoring	WAD	Cyanide	0.057	3E+00	1E+01
SDDENR electronic	460123	WWC	Site	35507	905	Water Quality Monitoring	WAD	Cyanide	0.055	3E+00	1E+01
SDDENR electronic	460123	WWC	Site	34073	1350	Water Quality Monitoring	WAD	Cyanide	0.043	2E+00	8E+00
SDDENR electronic	460123	WWC	Site	35696	1025	Water Quality Monitoring	WAD	Cyanide	0.042	2E+00	8E+00
SDDENR electronic	460123	WWC	Site	34681	1210	Water Quality Monitoring	WAD	Cyanide	0.015	7E-01	3E+00
SDDENR electronic	460686	WWC	Site	34709	915	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460123	WWC	Site	35632	1415	Water Quality Monitoring	WAD	Cyanide	0.015	7E-01	3E+00
SDDENR electronic	460123	WWC	Site	35150	1045	Water Quality Monitoring	WAD	Cyanide	0.07	3E+00	1E+01
SDDENR electronic	460123	WWC	Site	34311	1340	Water Quality Monitoring	WAD	Cyanide	0.023	1E+00	4E+00
SDDENR electronic	460123	WWC	Site	35660	1015	Water Quality Monitoring	WAD	Cyanide	0.02	9E-01	4E+00
SDDENR electronic	460123	WWC	Site	35606	820	Water Quality Monitoring	WAD	Cyanide	0.02	9E-01	4E+00
SDDENR electronic	460123	WWC	Site	35425	1030	Water Quality Monitoring	WAD	Cyanide	0.02	9E-01	4E+00
SDDENR electronic	460123	WWC	Site	35185	1340	Water Quality Monitoring	WAD	Cyanide	0.02	9E-01	4E+00
SDDENR electronic	460123	WWC	Site	35080	905	Water Quality Monitoring	WAD	Cyanide	0.02	9E-01	4E+00
SDDENR electronic	460123	WWC	Site	35730	1430	Water Quality Monitoring	WAD	Cyanide	0.019	9E-01	4E+00
SDDENR electronic	460123	WWC	Site	35844	1020	Water Quality Monitoring	WAD	Cyanide	0.035	2E+00	7E+00
SDDENR electronic	460684	WWC	Site	34877	1105	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460684	WWC	Site	35577	1105	Water Quality Monitoring	WAD	Cyanide	0.0025	1E-01	5E-01
SDDENR electronic	460684	WWC	Site	35234	1105	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460684	WWC	Site	35201	1030	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460684	WWC	Site	35045	1050	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460684	WWC	Site	35011	1050	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460684	WWC	Site	34989	810	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460684	WWC	Site	35325	1050	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460684	WWC	Site	35150	1150	Water Quality Monitoring	WAD	Cyanide	0.04	2E+00	8E+00
SDDENR electronic	460123	WWC	Site	34442	1430	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460684	WWC	Site	35991	750	Water Quality Monitoring	WAD	Cyanide	0.01	5E-01	2E+00
SDDENR electronic	460684	WWC	Site	34802	1320	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460684	WWC	Site	34648	815	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460684	WWC	Site	34611	1305	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460684	WWC	Site	34589	1030	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460684	WWC	Site	34470	1120	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460122	WWC	Site	35185	1315	Water Quality Monitoring	WAD	Cyanide	0.01	5E-01	2E+00
SDDENR electronic	460684	WWC	Site	34941	830	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460684	WWC	Site	35452	830	Water Quality Monitoring	WAD	Cyanide	0.011	5E-01	2E+00
SDDENR electronic	460684	WWC	Site	35429	910	Water Quality Monitoring	WAD	Cyanide	0.02	9E-01	4E+00
SDDENR electronic	460684	WWC	Site	35074	835	Water Quality Monitoring	WAD	Cyanide	0.02	9E-01	4E+00
SDDENR electronic	460684	WWC	Site	34752	1000	Water Quality Monitoring	WAD	Cyanide	0.02	9E-01	4E+00
SDDENR electronic	460684	WWC	Site	34772	1200	Water Quality Monitoring	WAD	Cyanide	0.042	2E+00	8E+00
SDDENR electronic	460684	WWC	Site	34703	1320	Water Quality Monitoring	WAD	Cyanide	0.016	7E-01	3E+00
SDDENR electronic	460684	WWC	Site	35696	1100	Water Quality Monitoring	WAD	Cyanide	0.045	2E+00	9E+00
SDDENR electronic	460684	WWC	Site	35297	810	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460684	WWC	Site	35109	1315	Water Quality Monitoring	WAD	Cyanide	0.012	5E-01	2E+00
SDDENR electronic	460684	WWC	Site	35507	1215	Water Quality Monitoring	WAD	Cyanide	0.081	4E+00	2E+01
SDDENR electronic	460684	WWC	Site	34969	1025	Water Quality Monitoring	WAD	Cyanide	0.011	5E-01	2E+00
SDDENR electronic	460684	WWC	Site	34416	1020	Water Quality Monitoring	WAD	Cyanide	0.011	5E-01	2E+00
SDDENR electronic	460123	WWC	Site	36661	0.503472222	Water Quality Monitoring Station	WAD	Cyanide	0.0025	1E-01	5E-01

**APPENDIX E**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Typ	Parameter	Adj Conc (ppm)	HQacute	HQchronic
SDDENR electronic	460123	WWC	Site	36306	0.5	Water Quality Monitoring Station	WAD	Cyanide	0.012	5E-01	2E+00
SDDENR electronic	460685	WWC	Site	35906	1440	Water Quality Monitoring	WAD	Cyanide	0.015	7E-01	3E+00
SDDENR electronic	460684	WWC	Site	34681	1140	Water Quality Monitoring	WAD	Cyanide	0.019	9E-01	4E+00
SDDENR electronic	460684	WWC	Site	34822	1100	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460684	WWC	Site	35633	825	Water Quality Monitoring	WAD	Cyanide	0.013	6E-01	3E+00
SDDENR electronic	460122	WWC	Site	36423	0.46875	Water Quality Monitoring Station	WAD	Cyanide	0.06	3E+00	1E+01
SDDENR electronic	460123	WWC	Site	34752	1035	Water Quality Monitoring	WAD	Cyanide	0.016	7E-01	3E+00
SDDENR electronic	460122	WWC	Site	36543	0.506944444	Water Quality Monitoring Station	WAD	Cyanide	0.051	2E+00	1E+01
SDDENR electronic	460122	WWC	Site	34442	1355	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460684	WWC	Site	36145	0.548611111	Water Quality Monitoring Station	WAD	Cyanide	0.017	8E-01	3E+00
SDDENR electronic	460122	WWC	Site	36641	0.489583333	Water Quality Monitoring Station	WAD	Cyanide	0.008	4E-01	2E+00
SDDENR electronic	460122	WWC	Site	36458	0.503472222	Water Quality Monitoring Station	WAD	Cyanide	0.018	8E-01	3E+00
SDDENR electronic	460682	WWC	Site	36544	0.586805556	Water Quality Monitoring Station	WAD	Cyanide	0.009	4E-01	2E+00
SDDENR electronic	460122	WWC	Site	36788	0.486111111	Water Quality Monitoring Station	WAD	Cyanide	0.0025	1E-01	5E-01
SDDENR electronic	460682	WWC	Site	36564	0.638888889	Water Quality Monitoring Station	WAD	Cyanide	0.009	4E-01	2E+00
SDDENR electronic	460122	WWC	Site	35544	1155	Water Quality Monitoring	WAD	Cyanide	0.07	3E+00	1E+01
SDDENR electronic	460122	WWC	Site	36144	0.576388889	Water Quality Monitoring Station	WAD	Cyanide	0.029	1E+00	6E+00
SDDENR electronic	460682	WWC	Site	35927	1245	Water Quality Monitoring	WAD	Cyanide	0.008	4E-01	2E+00
SDDENR electronic	460682	WWC	Site	36025	1515	Water Quality Monitoring	WAD	Cyanide	0.0025	1E-01	5E-01
SDDENR electronic	460682	WWC	Site	35991	1125	Water Quality Monitoring	WAD	Cyanide	0.0025	1E-01	5E-01
SDDENR electronic	460122	WWC	Site	36375	0.489583333	Water Quality Monitoring Station	WAD	Cyanide	0.033	2E+00	6E+00
SDDENR electronic	460684	WWC	Site	35660	1100	Water Quality Monitoring	WAD	Cyanide	0.022	1E+00	4E+00
SDDENR electronic	460122	WWC	Site	36081	0.565972222	Water Quality Monitoring Station	WAD	Cyanide	0.008	4E-01	2E+00
SDDENR electronic	460685	WWC	Site	34709	750	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460684	WWC	Site	34899	1255	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460682	WWC	Site	36145	0.475694444	Water Quality Monitoring Station	WAD	Cyanide	0.012	5E-01	2E+00
SDDENR electronic	460685	WWC	Site	35361	845	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460685	WWC	Site	35275	1445	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460685	WWC	Site	35080	800	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460685	WWC	Site	34988	1445	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460122	WWC	Site	36179	0.46875	Water Quality Monitoring Station	WAD	Cyanide	0.057	3E+00	1E+01
SDDENR electronic	460685	WWC	Site	34808	810	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460122	WWC	Site	36305	0.447916667	Water Quality Monitoring Station	WAD	Cyanide	0.016	7E-01	3E+00
SDDENR electronic	460685	WWC	Site	34631	1245	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460685	WWC	Site	34442	1450	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00
SDDENR electronic	460123	WWC	Site	34562	1020	Water Quality Monitoring	WAD	Cyanide	0.01	5E-01	2E+00
SDDENR electronic	460682	WWC	Site	36115	0.534722222	Water Quality Monitoring Station	WAD	Cyanide	0.012	5E-01	2E+00
SDDENR electronic	460682	WWC	Site	36375	0.333333333	Water Quality Monitoring Station	WAD	Cyanide	0.0025	1E-01	5E-01
SDDENR electronic	460682	WWC	Site	36180	0.534722222	Water Quality Monitoring Station	WAD	Cyanide	0.01	5E-01	2E+00
SDDENR electronic	460682	WWC	Site	36213	0.361111111	Water Quality Monitoring Station	WAD	Cyanide	0.007	3E-01	1E+00
SDDENR electronic	460685	WWC	Site	34898	800	Water Quality Monitoring	WAD	Cyanide	0.005	2E-01	1E+00

## **APPENDIX F**

### **DETAILED RISK CALCULATIONS FOR AQUATIC RECEPTORS FROM DIRECT CONTACT WITH SURFACE WATER - BASED ON SITE-SPECIFIC TOXICITY STANDARDS**

**APPENDIX F**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water - Site Stds**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Parameter	Adj Conc (mg/L)	State Stds (mg/L)	Hqchronic
SDDENR electronic	460122	WWC	Site	27-May-97	955	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	08-Nov-90	0.4375	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	09-Jun-98	0.378472222	Gaging Station	DISSOLVED	Copper	0.00427	0.080	5E-02
USGS electronic	6436198	WWC	Site	03-Jun-99	0.583333333	Gaging Station	DISSOLVED	Copper	0.003568	0.080	4E-02
SDDENR electronic	460122	WWC	Site	25-Jun-97	845	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460682	WWC	Site	23-Sep-97	1435	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460682	WWC	Site	14-Jan-98	910	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
EPA (1999) - Aquatic	WWC-09	WWC	Site	01-Sep-99	--	Field	Dissolved	Copper	0.003	0.080	4E-02
USGS electronic	6436180	WWC	Site	13-Dec-90	0.40625	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
SDDENR electronic	460122	WWC	Site	21-Jul-97	1310	Water Quality Monitoring	Dissolved	Copper	0.007	0.080	9E-02
SDDENR electronic	460682	WWC	Site	24-Mar-98	1450	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460682	WWC	Site	18-Feb-98	1245	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460122	WWC	Site	21-Apr-98	1355	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	06-Mar-91	0.520833333	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
SDDENR electronic	460122	WWC	Site	24-Mar-98	950	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460122	WWC	Site	16-Dec-97	1040	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460122	WWC	Site	13-Jan-98	940	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	05-May-99	0.447916667	Gaging Station	DISSOLVED	Copper	0.002349	0.080	3E-02
USGS electronic	6436180	WWC	Site	12-Sep-91	0.40625	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
SDDENR electronic	460682	WWC	Site	20-Apr-98	1220	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460682	WWC	Site	12-May-98	1245	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	13-Sep-99	0.517361111	Gaging Station	DISSOLVED	Copper	0.00366	0.080	5E-02
USGS electronic	6436180	WWC	Site	09-May-91	0.354166667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
SDDENR electronic	460123	WWC	Site	16-Dec-97	1105	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460684	WWC	Site	24-Nov-97	1100	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	21-Jun-90	0.75	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
SDDENR electronic	460122	WWC	Site	18-Feb-98	955	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	24-May-95	0.354166667	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
SDDENR electronic	460682	WWC	Site	28-Oct-97	1435	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	08-May-95	0.78125	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
SDDENR electronic	460682	WWC	Site	18-Aug-97	1325	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460682	WWC	Site	22-Jul-97	1220	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460682	WWC	Site	25-Jun-97	1500	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	24-May-94	0.465277778	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
SDDENR electronic	460682	WWC	Site	27-May-97	1305	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460122	WWC	Site	27-Oct-97	1355	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460682	WWC	Site	24-Nov-97	1245	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460122	WWC	Site	24-Nov-97	940	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460122	WWC	Site	18-Aug-97	950	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	26-Aug-97	0.354166667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
SDDENR electronic	460122	WWC	Site	23-Sep-97	955	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460682	WWC	Site	16-Dec-97	1525	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	21-Apr-94	0.322916667	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
SDDENR electronic	460123	WWC	Site	24-Mar-98	1015	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	07-Nov-90	0.510416667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
SDDENR electronic	460684	WWC	Site	16-Dec-97	1200	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
EPA (1999) - Aquatic	WWC-08	WWC	Site	01-Sep-99	--	Duplicate	Dissolved	Copper	0.0025	0.080	3E-02
USGS electronic	6436180	WWC	Site	03-Jun-99	0.4375	Gaging Station	DISSOLVED	Copper	0.003539	0.080	4E-02
USGS electronic	6436198	WWC	Site	24-May-95	0.5	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	09-Oct-90	0.479166667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
EPA (1999) - Aquatic	WWC-08	WWC	Site	01-Sep-99	--	Field	Dissolved	Copper	0.0026	0.080	3E-02
EPA (1999) - Aquatic	WWC-07	WWC	Site	01-Sep-99	--	Field	Dissolved	Copper	0.0025	0.080	3E-02
USGS electronic	6436180	WWC	Site	12-Feb-92	0.4375	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	21-Oct-91	0.447916667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02

**APPENDIX F**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water - Site Stds**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Parameter	Adj Conc (mg/L)	State Stds (mg/L)	Hqchronic
USGS electronic	6436180	WWC	Site	11-Mar-92	0.46875	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
USGS electronic	6436198	WWC	Site	21-Dec-94	0.375	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	12-Dec-90	0.479166667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	01-Sep-94	0.427083333	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	23-Jan-91	0.364583333	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	09-May-95	0.354166667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	25-May-96	0.416666667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	05-Jun-91	0.5	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	13-Sep-99	0.34375	Gaging Station	DISSOLVED	Copper	0.00285	0.080	4E-02
USGS electronic	6436198	WWC	Site	10-Jul-91	0.541666667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	10-Apr-91	0.354166667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	21-Apr-94	0.541666667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	30-Aug-95	0.510416667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	16-Mar-94	0.40625	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	08-Apr-92	0.59375	Gaging Station	DISSOLVED	Copper	0.03	0.080	4E-01
USGS electronic	6436198	WWC	Site	14-Aug-91	0.364583333	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	15-Feb-94	0.375	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	11-Sep-91	0.34375	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	11-Jun-92	0.447916667	Gaging Station	DISSOLVED	Copper	0.02	0.080	3E-01
USGS electronic	6436180	WWC	Site	28-Apr-92	0.520833333	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
USGS electronic	6436180	WWC	Site	14-Jul-93	0.385416667	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
USGS electronic	6436180	WWC	Site	06-May-93	0.552083333	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
USGS electronic	6436198	WWC	Site	06-Mar-91	0.354166667	Gaging Station	DISSOLVED	Copper	0.02	0.080	3E-01
USGS electronic	6436180	WWC	Site	16-Nov-92	0.4375	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	19-Feb-93	0.416666667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	17-Nov-92	0.46875	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	13-Oct-92	0.46875	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	09-Dec-92	0.520833333	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	15-Jun-93	0.395833333	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	15-Jul-93	0.395833333	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
EPA (1999) - Aquatic	SPC-R-12	OTHER	Ref	01-Sep-99	--	Field	Dissolved	Copper	0.001	0.080	1E-02
USGS electronic	6436198	WWC	Site	09-Sep-93	0.4375	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	26-Nov-91	0.375	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
EPA (1999) - Aquatic	WWC-05	WWC	Site	01-Sep-99	--	Field	Dissolved	Copper	0.0043	0.080	5E-02
USGS electronic	6436198	WWC	Site	19-Aug-93	0.416666667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	17-Dec-91	0.375	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	17-Mar-93	0.40625	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
USGS electronic	6436180	WWC	Site	23-Jan-91	0.604166667	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
USGS electronic	6436180	WWC	Site	09-Dec-92	0.388888889	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	08-May-91	0.447916667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	23-Oct-96	0.381944444	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	18-Mar-93	0.395833333	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	06-May-93	0.659722222	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	12-Jun-92	0.385416667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	15-Apr-93	0.375	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
EPA (1999) - Aquatic	WWC-02	WWC	Site	01-Sep-99	--	Field	Dissolved	Copper	0.0016	0.080	2E-02
EPA (1999) - Aquatic	WWC-03	WWC	Site	01-Sep-99	--	Field	Dissolved	Copper	0.0042	0.080	5E-02
USGS electronic	6436198	WWC	Site	14-Oct-92	0.364583333	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	02-Sep-92	0.489583333	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
USGS electronic	6436180	WWC	Site	25-Jun-96	0.461805556	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	28-Dec-93	0.395833333	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	03-Sep-92	0.291666667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	10-May-93	0.645833333	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	18-Aug-94	0.375	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02

**APPENDIX F**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water - Site Stds**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Parameter	Adj Conc (mg/L)	State Stds (mg/L)	Hqchronic
USGS electronic	6436198	WWC	Site	12-Aug-92	0.364583333	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
SDDENR electronic	460684	WWC	Site	28-Oct-97	1100	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460684	WWC	Site	27-May-97	1105	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460123	WWC	Site	24-Nov-97	1005	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460684	WWC	Site	22-Jul-97	825	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	01-Sep-94	0.333333333	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
SDDENR electronic	460123	WWC	Site	12-May-98	1025	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	15-Aug-90	0.375	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
SDDENR electronic	460684	WWC	Site	23-Sep-97	1100	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	30-Aug-95	0.334027778	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	31-May-90	0.395833333	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	15-Aug-91	0.34375	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
USGS electronic	6436180	WWC	Site	19-Jul-94	0.375	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
USGS electronic	6436180	WWC	Site	26-Apr-00	0.354166667	Water Quality Monitoring	Dissolved	Copper	0.002	0.080	3E-02
USGS electronic	6436180	WWC	Site	29-Dec-99	0.388888889	Water Quality Monitoring	Dissolved	Copper	0.004	0.080	5E-02
USGS electronic	6436198	WWC	Site	25-May-94	0.430555556	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
SDDENR electronic	460684	WWC	Site	18-Aug-97	1100	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	07-Sep-94	0.375	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	12-Feb-90	0.541666667	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
SDDENR electronic	460123	WWC	Site	21-Apr-98	1420	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460684	WWC	Site	18-Feb-98	1120	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460684	WWC	Site	24-Mar-98	1115	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460684	WWC	Site	20-Apr-98	835	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	28-Apr-98	0.4375	Gaging Station	DISSOLVED	Copper	0.001395	0.080	2E-02
SDDENR electronic	460684	WWC	Site	12-May-98	1100	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	29-Mar-90	0.520833333	Gaging Station	DISSOLVED	Copper	0.02	0.080	3E-01
SDDENR electronic	460684	WWC	Site	14-Jan-98	1315	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460684	WWC	Site	25-Jun-97	1135	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	11-Jun-91	0.354166667	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
USGS electronic	6436180	WWC	Site	07-May-97	0.427083333	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
USGS electronic	6436180	WWC	Site	26-Apr-90	0.510416667	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
USGS electronic	6436180	WWC	Site	16-Jun-00	0.326388889	Water Quality Monitoring	Dissolved	Copper	0.003	0.080	4E-02
SDDENR electronic	460123	WWC	Site	13-Jan-98	915	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460123	WWC	Site	25-Jun-97	820	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460686	WWC	Site	21-Jul-97	1230	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	22-Dec-97	0.416666667	Gaging Station	DISSOLVED	Copper	0.0028	0.080	4E-02
SDDENR electronic	460685	WWC	Site	21-Jul-97	1425	Water Quality Monitoring	Dissolved	Copper	0.009	0.080	1E-01
SDDENR electronic	460685	WWC	Site	27-Oct-97	1450	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460123	WWC	Site	21-Jul-97	1415	Water Quality Monitoring	Dissolved	Copper	0.008	0.080	1E-01
USGS electronic	6436180	WWC	Site	17-Aug-94	0.423611111	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
SDDENR electronic	460685	WWC	Site	21-Apr-98	1440	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	16-Jan-90	0.604166667	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
EPA (1999) - Aquatic	WWC-06	WWC	Site	01-Sep-99	--	Field	Dissolved	Copper	0.0027	0.080	3E-02
USGS electronic	6436180	WWC	Site	18-Aug-93	0.4375	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	20-Jul-94	0.375	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	21-Jun-94	0.395833333	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	10-May-93	0.4375	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
SDDENR electronic	460123	WWC	Site	18-Feb-98	1020	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460685	WWC	Site	13-Jan-98	840	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	10-Apr-91	0.53125	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
USGS electronic	6436180	WWC	Site	11-Sep-90	0.604166667	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
USGS electronic	6436180	WWC	Site	13-Sep-00	0.416666667	Water Quality Monitoring	Dissolved	Copper	0.004	0.080	5E-02
USGS electronic	6436180	WWC	Site	20-Dec-94	0.381944444	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
EPA (1999) - Aquatic	WWC-R-01 M	WWC	Ref	01-Sep-99	--	Field	Dissolved	Copper	0.0016	0.080	2E-02

**APPENDIX F**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water - Site Stds**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Parameter	Adj Conc (mg/L)	State Stds (mg/L)	Hqchronic
SDDENR electronic	460686	WWC	Site	21-Apr-98	1320	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460686	WWC	Site	13-Jan-98	1030	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	20-Jul-90	0.447916667	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
SDDENR electronic	460686	WWC	Site	27-Oct-97	1250	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	20-Jun-94	0.40625	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
SDDENR electronic	460123	WWC	Site	27-May-97	1025	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	11-Jul-91	0.40625	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
SDDENR electronic	460123	WWC	Site	27-Oct-97	1430	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460123	WWC	Site	23-Sep-97	1025	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
SDDENR electronic	460123	WWC	Site	18-Aug-97	1015	Water Quality Monitoring	Dissolved	Copper	0.005	0.080	6E-02
EPA (1999) - Aquatic	BFR-11	BFRd	Site	01-Sep-99	--	Field	Dissolved	Copper	0.0014	0.080	2E-02
USGS electronic	6436180	WWC	Site	09-Oct-90	0.635416667	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
USGS electronic	6436198	WWC	Site	15-Jan-92	0.5625	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	10-Mar-92	0.385416667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460684	WWC	Site	22-Jul-97	825	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
USGS electronic	6436198	WWC	Site	28-Dec-93	0.395833333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460123	WWC	Site	12-May-98	1025	Water Quality Monitoring	Dissolved	Silver	0.005	0.020	3E-01
SDDENR electronic	460123	WWC	Site	21-Apr-98	1420	Water Quality Monitoring	Dissolved	Silver	0.005	0.020	3E-01
SDDENR electronic	460123	WWC	Site	24-Mar-98	1015	Water Quality Monitoring	Dissolved	Silver	0.005	0.020	3E-01
USGS electronic	6436180	WWC	Site	11-Jun-92	0.447916667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	09-Sep-93	0.4375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	28-Apr-98	0.4375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460684	WWC	Site	28-Oct-97	1100	Water Quality Monitoring	Dissolved	Silver	0.005	0.020	3E-01
USGS electronic	6436198	WWC	Site	24-Oct-96	0.375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	24-May-95	0.354166667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	03-Jun-99	0.583333333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
EPA (1999) - Aquatic	WWC-09	WWC	Site	01-Sep-99	--	Duplicate	Dissolved	Silver	0.0025	0.020	1E-01
SDDENR electronic	460684	WWC	Site	12-May-98	1100	Water Quality Monitoring	Dissolved	Silver	0.005	0.020	3E-01
USGS electronic	6436198	WWC	Site	11-Feb-92	0.479166667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	08-Jan-96	0.520833333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460123	WWC	Site	27-May-97	1025	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
USGS electronic	6436198	WWC	Site	11-Sep-90	0.375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
EPA (1999) - Aquatic	BFR-11	BFRd	Site	01-Sep-99	--	Field	Dissolved	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	13-Sep-00	0.521527778	Water Quality Monitoring	Dissolved	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	18-Feb-93	0.447916667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
EPA (1999) - Aquatic	WWC-06	WWC	Site	01-Sep-99	--	Field	Dissolved	Silver	0.0014	0.020	7E-02
USGS electronic	6436180	WWC	Site	17-Aug-94	0.423611111	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	20-Aug-96	0.510416667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	20-Aug-96	0.375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	14-Jul-93	0.385416667	Gaging Station	DISSOLVED	Silver	0.001	0.020	5E-02
USGS electronic	6436180	WWC	Site	20-Jul-90	0.447916667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	16-Jun-93	0.385416667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
EPA (1999) - Aquatic	WWC-04	WWC	Site	01-Sep-99	--	Field	Dissolved	Silver	0.0011	0.020	6E-02
USGS electronic	6436180	WWC	Site	15-Aug-91	0.34375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	15-Mar-94	0.427083333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	20-Jun-94	0.40625	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460685	WWC	Site	21-Jul-97	1425	Water Quality Monitoring	Dissolved	Silver	0.03	0.020	2E+00
SDDENR electronic	460685	WWC	Site	21-Apr-98	1440	Water Quality Monitoring	Dissolved	Silver	0.02	0.020	1E+00
EPA (1999) - Aquatic	WWC-09	WWC	Site	01-Sep-99	--	Field	Dissolved	Silver	0.0025	0.020	1E-01
USGS electronic	6436180	WWC	Site	23-Jan-91	0.604166667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	06-Mar-91	0.354166667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460684	WWC	Site	20-Apr-98	835	Water Quality Monitoring	Dissolved	Silver	0.005	0.020	3E-01
USGS electronic	6436180	WWC	Site	12-Sep-91	0.40625	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	07-Jan-93	0.458333333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02

**APPENDIX F**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water - Site Stds**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Parameter	Adj Conc (mg/L)	State Stds (mg/L)	Hqchronic
USGS electronic	6436180	WWC	Site	15-Jun-93	0.395833333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	18-Mar-93	0.395833333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	11-Sep-90	0.604166667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	08-May-95	0.78125	Gaging Station	DISSOLVED	Silver	0.001	0.020	5E-02
USGS electronic	6436180	WWC	Site	24-May-94	0.465277778	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460122	WWC	Site	25-Jun-97	845	Water Quality Monitoring	Dissolved	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	05-May-99	0.447916667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460684	WWC	Site	18-Aug-97	1100	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
SDDENR electronic	460123	WWC	Site	18-Aug-97	1015	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
USGS electronic	6436198	WWC	Site	17-Nov-92	0.46875	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	09-Dec-92	0.520833333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460684	WWC	Site	23-Sep-97	1100	Water Quality Monitoring	Dissolved	Silver	0.005	0.020	3E-01
SDDENR electronic	460684	WWC	Site	14-Jan-98	1315	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
USGS electronic	6436180	WWC	Site	25-Jun-96	0.461805556	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460685	WWC	Site	27-Oct-97	1450	Water Quality Monitoring	Dissolved	Silver	0.01	0.020	5E-01
SDDENR electronic	460684	WWC	Site	24-Nov-97	1100	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
SDDENR electronic	460685	WWC	Site	13-Jan-98	840	Water Quality Monitoring	Dissolved	Silver	0.005	0.020	3E-01
USGS electronic	6436180	WWC	Site	07-Jan-97	0.427083333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	25-May-96	0.572916667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460684	WWC	Site	18-Feb-98	1120	Water Quality Monitoring	Dissolved	Silver	0.005	0.020	3E-01
USGS electronic	6436198	WWC	Site	23-Jan-91	0.364583333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	13-Oct-92	0.46875	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460684	WWC	Site	24-Mar-98	1115	Water Quality Monitoring	Dissolved	Silver	0.005	0.020	3E-01
SDDENR electronic	460684	WWC	Site	16-Dec-97	1200	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
USGS electronic	6436180	WWC	Site	21-Apr-94	0.322916667	Gaging Station	DISSOLVED	Lead	0.02	0.070	3E-01
USGS electronic	6436180	WWC	Site	08-Jan-96	0.520833333	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
SDDENR electronic	460684	WWC	Site	16-Dec-97	1200	Water Quality Monitoring	Dissolved	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	16-Aug-90	0.458333333	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	25-May-96	0.416666667	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436180	WWC	Site	14-Apr-93	0.395833333	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	07-May-97	0.427083333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	17-Aug-94	0.423611111	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
SDDENR electronic	460122	WWC	Site	18-Aug-97	950	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436198	WWC	Site	11-Sep-91	0.34375	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	15-Aug-90	0.375	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
SDDENR electronic	460685	WWC	Site	21-Apr-98	1440	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436180	WWC	Site	06-Jan-93	0.489583333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	09-Apr-92	0.40625	Gaging Station	DISSOLVED	Silver	0.001	0.020	5E-02
SDDENR electronic	460123	WWC	Site	25-Jun-97	820	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
USGS electronic	6436198	WWC	Site	16-Jun-00	0.482638889	Water Quality Monitoring	Dissolved	Lead	0.0005	0.070	7E-03
SDDENR electronic	460122	WWC	Site	13-Jan-98	940	Water Quality Monitoring	Dissolved	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	14-Jul-92	0.458333333	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
SDDENR electronic	460122	WWC	Site	21-Jul-97	1310	Water Quality Monitoring	Dissolved	Lead	0.003	0.070	4E-02
SDDENR electronic	460123	WWC	Site	13-Jan-98	915	Water Quality Monitoring	Dissolved	Lead	0.005	0.070	7E-02
EPA (1999) - Aquatic	WWC-05	WWC	Site	01-Sep-99	--	Field	Dissolved	Lead	0.001	0.070	1E-02
SDDENR electronic	460123	WWC	Site	16-Dec-97	1105	Water Quality Monitoring	Dissolved	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	15-Jan-92	0.5625	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	26-Apr-00	0.496527778	Water Quality Monitoring	Dissolved	Lead	0.0005	0.070	7E-03
SDDENR electronic	460122	WWC	Site	24-Mar-98	950	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436180	WWC	Site	15-Mar-94	0.427083333	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436198	WWC	Site	14-Aug-91	0.364583333	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
SDDENR electronic	460122	WWC	Site	27-May-97	955	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436198	WWC	Site	29-Dec-99	0.510416667	Water Quality Monitoring	Dissolved	Lead	0.0005	0.070	7E-03
USGS electronic	6436180	WWC	Site	14-Jul-93	0.385416667	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01

**APPENDIX F**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water - Site Stds**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Parameter	Adj Conc (mg/L)	State Stds (mg/L)	Hqchronic
SDDENR electronic	460685	WWC	Site	27-Oct-97	1450	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436180	WWC	Site	02-Sep-98	0.402777778	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460122	WWC	Site	21-Apr-98	1355	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436198	WWC	Site	16-Jun-00	0.482638889	Water Quality Monitoring	Dissolved	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	08-May-96	0.5625	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460123	WWC	Site	16-Dec-97	1105	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
SDDENR electronic	460123	WWC	Site	27-Oct-97	1430	Water Quality Monitoring	Dissolved	Silver	0.005	0.020	3E-01
USGS electronic	6436198	WWC	Site	09-Jan-96	0.479166667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460123	WWC	Site	23-Sep-97	1025	Water Quality Monitoring	Dissolved	Silver	0.005	0.020	3E-01
USGS electronic	6436180	WWC	Site	14-Jul-92	0.458333333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	26-Apr-00	0.496527778	Water Quality Monitoring	Dissolved	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	09-Oct-90	0.635416667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	13-Sep-00	0.520833333	Water Quality Monitoring	Dissolved	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	26-Aug-97	0.354166667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460123	WWC	Site	13-Jan-98	915	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
SDDENR electronic	460123	WWC	Site	18-Feb-98	1020	Water Quality Monitoring	Dissolved	Silver	0.005	0.020	3E-01
SDDENR electronic	460123	WWC	Site	24-Nov-97	1005	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
USGS electronic	6436198	WWC	Site	19-Feb-93	0.416666667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	29-Dec-99	0.510416667	Water Quality Monitoring	Dissolved	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	09-Jun-98	0.524305556	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	21-Apr-94	0.322916667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	15-Jul-93	0.395833333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	22-Oct-91	0.322916667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
EPA (1999) - Aquatic	BFR-R-10	BFRu	Ref	01-Sep-99	--	Field	Dissolved	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	11-Jun-91	0.354166667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	10-Apr-91	0.53125	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	19-Aug-93	0.416666667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	10-May-93	0.4375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	30-Aug-95	0.334027778	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	09-Jun-98	0.378472222	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	19-Jul-94	0.375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	15-Aug-90	0.375	Gaging Station	DISSOLVED	Silver	0.001	0.020	5E-02
USGS electronic	6436198	WWC	Site	09-Oct-90	0.479166667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	08-Jan-97	0.430555556	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460123	WWC	Site	21-Jul-97	1415	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
USGS electronic	6436198	WWC	Site	08-May-91	0.447916667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	18-Aug-93	0.4375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	02-Sep-92	0.489583333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	26-Nov-91	0.375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	22-Dec-97	0.416666667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460686	WWC	Site	21-Jul-97	1230	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
USGS electronic	6436180	WWC	Site	14-Feb-94	0.423611111	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460682	WWC	Site	24-Mar-98	1450	Water Quality Monitoring	Dissolved	Silver	0.005	0.020	3E-01
USGS electronic	6436198	WWC	Site	11-Sep-91	0.34375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460682	WWC	Site	25-Jun-97	1500	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
SDDENR electronic	460686	WWC	Site	21-Apr-98	1320	Water Quality Monitoring	Dissolved	Silver	0.005	0.020	3E-01
USGS electronic	6436198	WWC	Site	16-Mar-94	0.40625	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	29-Apr-98	0.423611111	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460686	WWC	Site	27-Oct-97	1250	Water Quality Monitoring	Dissolved	Silver	0.005	0.020	3E-01
SDDENR electronic	460686	WWC	Site	13-Jan-98	1030	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
USGS electronic	6436180	WWC	Site	08-Nov-90	0.4375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	13-Sep-00	0.416666667	Water Quality Monitoring	Dissolved	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	17-Mar-93	0.40625	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	11-Jul-91	0.40625	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02

**APPENDIX F**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water - Site Stds**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Parameter	Adj Conc (mg/L)	State Stds (mg/L)	Hqchronic
USGS electronic	6436198	WWC	Site	12-Feb-90	0.375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	10-Jul-91	0.541666667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460682	WWC	Site	28-Oct-97	1435	Water Quality Monitoring	Dissolved	Silver	0.005	0.020	3E-01
EPA (1999) - Aquatic	WWC-05	WWC	Site	01-Sep-99	--	Field	Dissolved	Silver	0.0005	0.020	3E-02
EPA (1999) - Aquatic	WWC-09	WWC	Site	01-Sep-99	--	Extra (collocated with fish sample)	Dissolved	Silver	0.0025	0.020	1E-01
USGS electronic	6436180	WWC	Site	13-Sep-99	0.34375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	26-Aug-97	0.520833333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
EPA (1999) - Aquatic	WWC-02	WWC	Site	01-Sep-99	--	Field	Dissolved	Silver	0.0012	0.020	6E-02
SDDENR electronic	460682	WWC	Site	18-Aug-97	1325	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
USGS electronic	6436198	WWC	Site	23-Dec-97	0.375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460682	WWC	Site	22-Jul-97	1220	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
USGS electronic	6436198	WWC	Site	21-Jun-94	0.395833333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460682	WWC	Site	18-Feb-98	1245	Water Quality Monitoring	Dissolved	Silver	0.005	0.020	3E-01
USGS electronic	6436198	WWC	Site	16-Aug-90	0.458333333	Gaging Station	DISSOLVED	Silver	0.001	0.020	5E-02
USGS electronic	6436180	WWC	Site	03-Jun-99	0.4375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	20-Dec-94	0.381944444	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	09-May-91	0.354166667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	30-Aug-95	0.510416667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	08-May-97	0.375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	28-Apr-92	0.520833333	Gaging Station	DISSOLVED	Silver	0.001	0.020	5E-02
USGS electronic	6436180	WWC	Site	14-Apr-93	0.395833333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	17-Jan-90	0.416666667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	18-Aug-94	0.375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
EPA (1999) - Aquatic	WWC-08	WWC	Site	01-Sep-99	--	Duplicate	Dissolved	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	19-Jul-90	0.395833333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	30-May-90	0.447916667	Gaging Station	DISSOLVED	Silver	0.002	0.020	1E-01
USGS electronic	6436198	WWC	Site	15-Jan-92	0.5625	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	16-Dec-98	0.416666667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	01-Sep-94	0.427083333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	07-Sep-94	0.375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	09-Sep-93	0.322916667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460682	WWC	Site	24-Nov-97	1245	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
USGS electronic	6436180	WWC	Site	11-Mar-92	0.46875	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	26-Apr-90	0.510416667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	21-Dec-94	0.375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	21-Jun-90	0.510416667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	23-Oct-96	0.381944444	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	01-Sep-94	0.333333333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	31-May-90	0.395833333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	23-Apr-90	0.395833333	Gaging Station	DISSOLVED	Silver	0.002	0.020	1E-01
USGS electronic	6436198	WWC	Site	09-May-95	0.354166667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	14-Aug-91	0.364583333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	21-Oct-91	0.447916667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	12-Feb-92	0.4375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	24-May-95	0.5	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	13-Dec-90	0.40625	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	05-Jun-91	0.5	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	15-Apr-93	0.375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460122	WWC	Site	18-Feb-98	955	Water Quality Monitoring	Dissolved	Silver	0.005	0.020	3E-01
SDDENR electronic	460122	WWC	Site	24-Mar-98	950	Water Quality Monitoring	Dissolved	Silver	0.005	0.020	3E-01
SDDENR electronic	460122	WWC	Site	27-May-97	955	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
USGS electronic	6436198	WWC	Site	06-May-93	0.659722222	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460684	WWC	Site	25-Jun-97	1135	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
USGS electronic	6436180	WWC	Site	08-May-96	0.361111111	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02

**APPENDIX F**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water - Site Stds**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Parameter	Adj Conc (mg/L)	State Stds (mg/L)	Hqchronic
USGS electronic	6436198	WWC	Site	12-Dec-90	0.479166667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460122	WWC	Site	13-Jan-98	940	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
USGS electronic	6436198	WWC	Site	14-Oct-92	0.364583333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
EPA (1999) - Aquatic	SPC-R-12	OTHER	Ref	01-Sep-99	--	Field	Dissolved	Silver	0.0013	0.020	7E-02
USGS electronic	6436180	WWC	Site	12-Feb-90	0.541666667	Gaging Station	DISSOLVED	Silver	0.001	0.020	5E-02
USGS electronic	6436180	WWC	Site	29-Mar-90	0.520833333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
EPA (1999) - Aquatic	WWC-03	WWC	Site	01-Sep-99	--	Field	Dissolved	Silver	0.0005	0.020	3E-02
SDDENR electronic	460682	WWC	Site	16-Dec-97	1525	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
SDDENR electronic	460684	WWC	Site	27-May-97	1105	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
USGS electronic	6436180	WWC	Site	16-Nov-92	0.4375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460122	WWC	Site	21-Jul-97	1310	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
USGS electronic	6436198	WWC	Site	12-Jun-92	0.385416667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	07-Nov-90	0.510416667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	10-Apr-91	0.354166667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	05-May-99	0.354166667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	02-Sep-98	0.559027778	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460122	WWC	Site	27-Oct-97	1355	Water Quality Monitoring	Dissolved	Silver	0.005	0.020	3E-01
USGS electronic	6436180	WWC	Site	16-Jan-92	0.375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460122	WWC	Site	23-Sep-97	955	Water Quality Monitoring	Dissolved	Silver	0.005	0.020	3E-01
SDDENR electronic	460122	WWC	Site	25-Jun-97	845	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
USGS electronic	6436198	WWC	Site	26-Jun-96	0.340277778	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460122	WWC	Site	18-Aug-97	950	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
SDDENR electronic	460122	WWC	Site	24-Nov-97	940	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
SDDENR electronic	460122	WWC	Site	16-Dec-97	1040	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
USGS electronic	6436198	WWC	Site	13-Sep-99	0.517361111	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	29-Apr-92	0.385416667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	16-Jan-90	0.604166667	Gaging Station	DISSOLVED	Silver	0.001	0.020	5E-02
USGS electronic	6436198	WWC	Site	17-Dec-91	0.375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	20-Jul-94	0.375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	21-Jun-90	0.75	Gaging Station	DISSOLVED	Silver	0.001	0.020	5E-02
SDDENR electronic	460682	WWC	Site	12-May-98	1245	Water Quality Monitoring	Dissolved	Silver	0.005	0.020	3E-01
USGS electronic	6436180	WWC	Site	26-Apr-00	0.354166667	Water Quality Monitoring	Dissolved	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	16-Dec-98	0.59375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	16-Jun-00	0.326388889	Water Quality Monitoring	Dissolved	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	06-May-93	0.552083333	Gaging Station	DISSOLVED	Silver	0.001	0.020	5E-02
SDDENR electronic	460682	WWC	Site	14-Jan-98	910	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
USGS electronic	6436180	WWC	Site	06-Mar-91	0.520833333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	27-Dec-93	0.375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
EPA (1999) - Aquatic	WWC-08	WWC	Site	01-Sep-99	--	Field	Dissolved	Silver	0.0018	0.020	9E-02
USGS electronic	6436180	WWC	Site	08-Apr-92	0.59375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	11-Jun-91	0.354166667	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436198	WWC	Site	15-Feb-94	0.375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	27-Nov-91	0.375	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
EPA (1999) - Aquatic	WWC-07	WWC	Site	01-Sep-99	--	Field	Dissolved	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	11-Aug-92	0.364583333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	12-Aug-92	0.364583333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	09-Dec-92	0.388888889	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	10-May-93	0.645833333	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	17-Dec-91	0.572916667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	29-Mar-90	0.354166667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	03-Sep-92	0.291666667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460682	WWC	Site	27-May-97	1305	Water Quality Monitoring	Dissolved	Silver	0.0025	0.020	1E-01
EPA (1999) - Aquatic	WWC-R-01 M	WWC	Ref	01-Sep-99	--	Field	Dissolved	Silver	0.0014	0.020	7E-02
SDDENR electronic	460682	WWC	Site	20-Apr-98	1220	Water Quality Monitoring	Dissolved	Silver	0.005	0.020	3E-01

**APPENDIX F**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water - Site Stds**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Parameter	Adj Conc (mg/L)	State Stds (mg/L)	Hqchronic
USGS electronic	6436180	WWC	Site	25-May-96	0.416666667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436180	WWC	Site	29-Dec-99	0.388888889	Water Quality Monitoring	Dissolved	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	25-May-94	0.430555556	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
SDDENR electronic	460682	WWC	Site	23-Sep-97	1435	Water Quality Monitoring	Dissolved	Silver	0.005	0.020	3E-01
SDDENR electronic	460122	WWC	Site	21-Apr-98	1355	Water Quality Monitoring	Dissolved	Silver	0.005	0.020	3E-01
USGS electronic	6436180	WWC	Site	23-Jan-91	0.604166667	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436180	WWC	Site	11-Jun-92	0.447916667	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436180	WWC	Site	26-Apr-00	0.354166667	Water Quality Monitoring	Dissolved	Lead	0.0005	0.070	7E-03
USGS electronic	6436180	WWC	Site	16-Jun-00	0.326388889	Water Quality Monitoring	Dissolved	Lead	0.0005	0.070	7E-03
USGS electronic	6436198	WWC	Site	24-Oct-96	0.375	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	08-Nov-90	0.4375	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436198	WWC	Site	20-Aug-96	0.510416667	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
SDDENR electronic	460123	WWC	Site	25-Jun-97	820	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436180	WWC	Site	24-May-95	0.354166667	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	06-Jan-93	0.489583333	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	29-Apr-92	0.385416667	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
SDDENR electronic	460123	WWC	Site	18-Aug-97	1015	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436198	WWC	Site	09-Apr-92	0.40625	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436180	WWC	Site	23-Oct-96	0.381944444	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436180	WWC	Site	17-Dec-91	0.572916667	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
SDDENR electronic	460123	WWC	Site	27-Oct-97	1430	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436180	WWC	Site	16-Jan-92	0.375	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	07-Sep-94	0.375	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
EPA (1999) - Aquatic	WWC-03	WWC	Site	01-Sep-99	--	Field	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436180	WWC	Site	05-May-99	0.354166667	Gaging Station	DISSOLVED	Lead	0.0005	0.070	7E-03
USGS electronic	6436180	WWC	Site	09-Jun-98	0.378472222	Gaging Station	DISSOLVED	Lead	0.001	0.070	1E-02
USGS electronic	6436180	WWC	Site	15-Aug-91	0.34375	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436180	WWC	Site	29-Dec-99	0.388888889	Water Quality Monitoring	Dissolved	Lead	0.0005	0.070	7E-03
SDDENR electronic	460123	WWC	Site	21-Jul-97	1415	Water Quality Monitoring	Dissolved	Lead	0.006	0.070	9E-02
USGS electronic	6436198	WWC	Site	08-May-96	0.5625	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	11-Feb-92	0.479166667	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
SDDENR electronic	460123	WWC	Site	18-Feb-98	1020	Water Quality Monitoring	Dissolved	Lead	0.006	0.070	9E-02
SDDENR electronic	460123	WWC	Site	12-May-98	1025	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436198	WWC	Site	26-Jun-96	0.340277778	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	18-Feb-93	0.447916667	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
SDDENR electronic	460123	WWC	Site	24-Nov-97	1005	Water Quality Monitoring	Dissolved	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	25-May-96	0.572916667	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	23-Dec-97	0.375	Gaging Station	DISSOLVED	Lead	0.0005	0.070	7E-03
USGS electronic	6436180	WWC	Site	13-Sep-00	0.416666667	Water Quality Monitoring	Dissolved	Lead	0.0005	0.070	7E-03
USGS electronic	6436180	WWC	Site	14-Jul-92	0.458333333	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	11-Aug-92	0.364583333	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	07-Jan-97	0.427083333	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	10-May-93	0.645833333	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
SDDENR electronic	460123	WWC	Site	23-Sep-97	1025	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
SDDENR electronic	460686	WWC	Site	21-Jul-97	1230	Water Quality Monitoring	Dissolved	Lead	0.002	0.070	3E-02
SDDENR electronic	460682	WWC	Site	18-Aug-97	1325	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436180	WWC	Site	02-Sep-98	0.402777778	Gaging Station	DISSOLVED	Lead	0.0005	0.070	7E-03
USGS electronic	6436198	WWC	Site	25-May-94	0.430555556	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	29-Apr-98	0.423611111	Gaging Station	DISSOLVED	Lead	0.0005	0.070	7E-03
SDDENR electronic	460682	WWC	Site	20-Apr-98	1220	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436198	WWC	Site	28-Dec-93	0.395833333	Gaging Station	DISSOLVED	Lead	0.02	0.070	3E-01
SDDENR electronic	460122	WWC	Site	23-Sep-97	955	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436198	WWC	Site	21-Jun-94	0.395833333	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
SDDENR electronic	460682	WWC	Site	22-Jul-97	1220	Water Quality Monitoring	Dissolved	Lead	0.002	0.070	3E-02

**APPENDIX F**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water - Site Stds**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Parameter	Adj Conc (mg/L)	State Stds (mg/L)	Hqchronic
USGS electronic	6436198	WWC	Site	03-Sep-92	0.291666667	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
SDDENR electronic	460122	WWC	Site	27-Oct-97	1355	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
EPA (1999) - Aquatic	WWC-04	WWC	Site	01-Sep-99	--	Field	Dissolved	Lead	0.001	0.070	1E-02
SDDENR electronic	460123	WWC	Site	24-Mar-98	1015	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
SDDENR electronic	460123	WWC	Site	21-Apr-98	1420	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436198	WWC	Site	10-Mar-92	0.385416667	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	12-Sep-91	0.40625	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	09-Jan-96	0.479166667	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	02-Sep-98	0.559027778	Gaging Station	DISSOLVED	Lead	0.0005	0.070	7E-03
EPA (1999) - Aquatic	BFR-11	BFRd	Site	01-Sep-99	--	Field	Dissolved	Lead	0.001	0.070	1E-02
SDDENR electronic	460682	WWC	Site	14-Jan-98	910	Water Quality Monitoring	Dissolved	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	22-Oct-91	0.322916667	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
SDDENR electronic	460682	WWC	Site	28-Oct-97	1435	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
SDDENR electronic	460682	WWC	Site	23-Sep-97	1435	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
SDDENR electronic	460123	WWC	Site	27-May-97	1025	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436198	WWC	Site	08-Jan-97	0.430555556	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	16-Jun-00	0.482638889	Water Quality Monitoring	Dissolved	Copper	0.003	0.080	4E-02
USGS electronic	6436198	WWC	Site	29-Dec-99	0.510416667	Water Quality Monitoring	Dissolved	Copper	0.004	0.080	5E-02
USGS electronic	6436198	WWC	Site	08-Jan-97	0.430555556	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	16-Jan-92	0.375	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	17-Dec-91	0.572916667	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
USGS electronic	6436198	WWC	Site	21-Jun-90	0.510416667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	30-May-90	0.447916667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	09-Sep-93	0.322916667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	15-Mar-94	0.427083333	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
USGS electronic	6436198	WWC	Site	11-Sep-90	0.375	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	26-Aug-97	0.520833333	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	13-Sep-00	0.520833333	Water Quality Monitoring	Dissolved	Copper	0.003	0.080	4E-02
USGS electronic	6436180	WWC	Site	05-May-99	0.354166667	Gaging Station	DISSOLVED	Copper	0.0012185	0.080	2E-02
USGS electronic	6436180	WWC	Site	27-Nov-91	0.375	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
USGS electronic	6436180	WWC	Site	25-Jun-96	0.461805556	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	26-Apr-00	0.496527778	Water Quality Monitoring	Dissolved	Copper	0.003	0.080	4E-02
USGS electronic	6436198	WWC	Site	09-Apr-92	0.40625	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	21-Apr-94	0.541666667	Gaging Station	DISSOLVED	Silver	0.0005	0.020	3E-02
USGS electronic	6436198	WWC	Site	29-Apr-92	0.385416667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	20-Aug-96	0.375	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	11-Feb-92	0.479166667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	16-Jun-93	0.385416667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	10-Mar-92	0.385416667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	23-Dec-97	0.375	Gaging Station	DISSOLVED	Copper	0.00218	0.080	3E-02
EPA (1999) - Aquatic	WWC-04	WWC	Site	01-Sep-99	--	Field	Dissolved	Copper	0.0054	0.080	7E-02
USGS electronic	6436180	WWC	Site	27-Dec-93	0.375	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	11-Aug-92	0.364583333	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	14-Apr-93	0.395833333	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
EPA (1999) - Aquatic	BFR-R-10	BFRu	Ref	01-Sep-99	--	Field	Dissolved	Copper	0.0005	0.080	6E-03
USGS electronic	6436198	WWC	Site	29-Mar-90	0.354166667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	07-Jan-97	0.427083333	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	20-Aug-96	0.510416667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	18-Feb-93	0.447916667	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
USGS electronic	6436198	WWC	Site	12-Aug-92	0.364583333	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	25-May-96	0.572916667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	17-Jan-90	0.416666667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	14-Feb-94	0.423611111	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	09-Jun-98	0.524305556	Gaging Station	DISSOLVED	Copper	0.00327	0.080	4E-02

**APPENDIX F**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water - Site Stds**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Parameter	Adj Conc (mg/L)	State Stds (mg/L)	Hqchronic
USGS electronic	6436180	WWC	Site	08-May-96	0.361111111	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	13-Sep-00	0.521527778	Water Quality Monitoring	Dissolved	Copper	0.003	0.080	4E-02
USGS electronic	6436198	WWC	Site	12-Feb-90	0.375	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	08-May-97	0.375	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	13-Sep-99	0.517361111	Gaging Station	DISSOLVED	Lead	0.0005	0.070	7E-03
USGS electronic	6436180	WWC	Site	12-Feb-92	0.4375	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	09-Dec-92	0.388888889	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436198	WWC	Site	08-May-97	0.375	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	30-Aug-95	0.510416667	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
SDDENR electronic	460682	WWC	Site	12-May-98	1245	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
EPA (1999) - Aquatic	WWC-09	WWC	Site	01-Sep-99	--	Extra (collocated with fish sample)	Dissolved	Copper	0.003	0.080	4E-02
EPA (1999) - Aquatic	WWC-09	WWC	Site	01-Sep-99	--	Duplicate	Dissolved	Copper	0.003	0.080	4E-02
USGS electronic	6436198	WWC	Site	24-Oct-96	0.375	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	23-Apr-90	0.395833333	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	07-Jan-93	0.458333333	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	26-Jun-96	0.340277778	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	16-Dec-98	0.416666667	Gaging Station	DISSOLVED	Copper	0.001538	0.080	2E-02
USGS electronic	6436180	WWC	Site	02-Sep-98	0.402777778	Gaging Station	DISSOLVED	Copper	0.00183	0.080	2E-02
USGS electronic	6436198	WWC	Site	19-Jul-90	0.395833333	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	16-Dec-98	0.59375	Gaging Station	DISSOLVED	Copper	0.002554	0.080	3E-02
USGS electronic	6436198	WWC	Site	02-Sep-98	0.559027778	Gaging Station	DISSOLVED	Copper	0.00301	0.080	4E-02
USGS electronic	6436198	WWC	Site	29-Apr-98	0.423611111	Gaging Station	DISSOLVED	Copper	0.00242	0.080	3E-02
USGS electronic	6436198	WWC	Site	09-Jan-96	0.479166667	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	22-Oct-91	0.322916667	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
USGS electronic	6436180	WWC	Site	08-Jan-96	0.520833333	Gaging Station	DISSOLVED	Copper	0.01	0.080	1E-01
USGS electronic	6436198	WWC	Site	08-May-96	0.5625	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436198	WWC	Site	12-Jun-92	0.385416667	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436198	WWC	Site	16-Aug-90	0.458333333	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	20-Jun-94	0.40625	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436198	WWC	Site	15-Feb-94	0.375	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
SDDENR electronic	460684	WWC	Site	23-Sep-97	1100	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
SDDENR electronic	460684	WWC	Site	18-Aug-97	1100	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436198	WWC	Site	06-Mar-91	0.354166667	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	07-May-97	0.427083333	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436180	WWC	Site	29-Mar-90	0.520833333	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
SDDENR electronic	460684	WWC	Site	28-Oct-97	1100	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436198	WWC	Site	13-Sep-00	0.520833333	Water Quality Monitoring	Dissolved	Lead	0.0005	0.070	7E-03
USGS electronic	6436180	WWC	Site	28-Apr-98	0.4375	Gaging Station	DISSOLVED	Lead	0.0005	0.070	7E-03
SDDENR electronic	460684	WWC	Site	24-Mar-98	1115	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436198	WWC	Site	23-Apr-90	0.395833333	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	27-Dec-93	0.375	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
SDDENR electronic	460684	WWC	Site	18-Feb-98	1120	Water Quality Monitoring	Dissolved	Lead	0.0025	0.070	4E-02
USGS electronic	6436180	WWC	Site	15-Jun-93	0.395833333	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436198	WWC	Site	30-May-90	0.447916667	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
SDDENR electronic	460684	WWC	Site	24-Nov-97	1100	Water Quality Monitoring	Dissolved	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	09-May-91	0.354166667	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436180	WWC	Site	22-Dec-97	0.416666667	Gaging Station	DISSOLVED	Lead	0.0005	0.070	7E-03
USGS electronic	6436198	WWC	Site	12-Feb-90	0.375	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	11-Sep-90	0.604166667	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436180	WWC	Site	30-Aug-95	0.334027778	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	21-Jun-90	0.75	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436180	WWC	Site	20-Jul-90	0.447916667	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436180	WWC	Site	12-Feb-90	0.541666667	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
EPA (1999) - Aquatic	WWC-08	WWC	Site	01-Sep-99	--	Field	Dissolved	Lead	0.001	0.070	1E-02

**APPENDIX F**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water - Site Stds**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Parameter	Adj Conc (mg/L)	State Stds (mg/L)	Hqchronic
USGS electronic	6436180	WWC	Site	16-Jan-90	0.604166667	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436180	WWC	Site	11-Jul-91	0.40625	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
SDDENR electronic	460685	WWC	Site	13-Jan-98	840	Water Quality Monitoring	Dissolved	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	13-Sep-00	0.521527778	Water Quality Monitoring	Dissolved	Lead	0.0005	0.070	7E-03
SDDENR electronic	460685	WWC	Site	21-Jul-97	1425	Water Quality Monitoring	Dissolved	Lead	0.007	0.070	1E-01
EPA (1999) - Aquatic	WWC-08	WWC	Site	01-Sep-99	--	Duplicate	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436198	WWC	Site	26-Nov-91	0.375	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	07-Nov-90	0.510416667	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	19-Jul-94	0.375	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436180	WWC	Site	09-Oct-90	0.635416667	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436180	WWC	Site	01-Sep-94	0.333333333	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436198	WWC	Site	11-Sep-90	0.375	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	10-Jul-91	0.541666667	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	10-Apr-91	0.53125	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
EPA (1999) - Aquatic	WWC-09	WWC	Site	01-Sep-99	--	Duplicate	Dissolved	Lead	0.0005	0.070	7E-03
USGS electronic	6436198	WWC	Site	09-Oct-90	0.479166667	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
SDDENR electronic	460122	WWC	Site	16-Dec-97	1040	Water Quality Monitoring	Dissolved	Lead	0.005	0.070	7E-02
SDDENR electronic	460684	WWC	Site	14-Jan-98	1315	Water Quality Monitoring	Dissolved	Lead	0.005	0.070	7E-02
SDDENR electronic	460122	WWC	Site	18-Feb-98	955	Water Quality Monitoring	Dissolved	Lead	0.0025	0.070	4E-02
USGS electronic	6436180	WWC	Site	17-Mar-93	0.40625	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	17-Dec-91	0.375	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	08-May-96	0.361111111	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
SDDENR electronic	460684	WWC	Site	27-May-97	1105	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436198	WWC	Site	19-Jul-90	0.395833333	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	21-Jun-90	0.510416667	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	29-Mar-90	0.354166667	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	10-Apr-91	0.354166667	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
SDDENR electronic	460684	WWC	Site	20-Apr-98	835	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436198	WWC	Site	23-Jan-91	0.364583333	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	18-Aug-93	0.4375	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
SDDENR electronic	460684	WWC	Site	12-May-98	1100	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436198	WWC	Site	21-Oct-91	0.447916667	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	10-May-93	0.4375	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436180	WWC	Site	26-Apr-90	0.510416667	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
SDDENR electronic	460684	WWC	Site	22-Jul-97	825	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
SDDENR electronic	460122	WWC	Site	24-Nov-97	940	Water Quality Monitoring	Dissolved	Lead	0.005	0.070	7E-02
EPA (1999) - Aquatic	WWC-09	WWC	Site	01-Sep-99	--	Field	Dissolved	Lead	0.0005	0.070	7E-03
EPA (1999) - Aquatic	WWC-07	WWC	Site	01-Sep-99	--	Field	Dissolved	Lead	0.001	0.070	1E-02
SDDENR electronic	460684	WWC	Site	25-Jun-97	1135	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436198	WWC	Site	26-Aug-97	0.520833333	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	07-Jan-93	0.458333333	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	16-Dec-98	0.416666667	Gaging Station	DISSOLVED	Lead	0.0005	0.070	7E-03
USGS electronic	6436198	WWC	Site	09-Dec-92	0.520833333	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	21-Dec-94	0.375	Gaging Station	DISSOLVED	Lead	0.03	0.070	4E-01
USGS electronic	6436198	WWC	Site	16-Jun-93	0.385416667	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
EPA (1999) - Aquatic	WWC-02	WWC	Site	01-Sep-99	--	Field	Dissolved	Lead	0.001	0.070	1E-02
SDDENR electronic	460682	WWC	Site	27-May-97	1305	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436180	WWC	Site	06-Mar-91	0.520833333	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436198	WWC	Site	17-Nov-92	0.46875	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	09-May-95	0.354166667	Gaging Station	DISSOLVED	Lead	0.04	0.070	6E-01
USGS electronic	6436180	WWC	Site	08-May-95	0.78125	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436198	WWC	Site	24-May-95	0.5	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	03-Jun-99	0.4375	Gaging Station	DISSOLVED	Lead	0.001	0.070	1E-02
USGS electronic	6436198	WWC	Site	17-Jan-90	0.416666667	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02

**APPENDIX F**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water - Site Stds**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Parameter	Adj Conc (mg/L)	State Stds (mg/L)	Hqchronic
USGS electronic	6436198	WWC	Site	19-Feb-93	0.416666667	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
SDDENR electronic	460682	WWC	Site	24-Nov-97	1245	Water Quality Monitoring	Dissolved	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	09-Sep-93	0.4375	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
SDDENR electronic	460682	WWC	Site	24-Mar-98	1450	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436198	WWC	Site	15-Jul-93	0.395833333	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	09-Jun-98	0.524305556	Gaging Station	DISSOLVED	Lead	0.0005	0.070	7E-03
SDDENR electronic	460682	WWC	Site	16-Dec-97	1525	Water Quality Monitoring	Dissolved	Lead	0.005	0.070	7E-02
SDDENR electronic	460682	WWC	Site	18-Feb-98	1245	Water Quality Monitoring	Dissolved	Lead	0.0025	0.070	4E-02
USGS electronic	6436180	WWC	Site	13-Oct-92	0.46875	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	21-Apr-94	0.541666667	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
SDDENR electronic	460686	WWC	Site	27-Oct-97	1250	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436180	WWC	Site	20-Aug-96	0.375	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
EPA (1999) - Aquatic	BFR-R-10	BFRu	Ref	01-Sep-99	--	Field	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436180	WWC	Site	28-Apr-92	0.520833333	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436198	WWC	Site	16-Dec-98	0.59375	Gaging Station	DISSOLVED	Lead	0.0005	0.070	7E-03
USGS electronic	6436198	WWC	Site	16-Mar-94	0.40625	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	26-Aug-97	0.354166667	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436198	WWC	Site	19-Aug-93	0.416666667	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	08-May-91	0.447916667	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	13-Dec-90	0.40625	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436198	WWC	Site	05-May-99	0.447916667	Gaging Station	DISSOLVED	Lead	0.0005	0.070	7E-03
USGS electronic	6436198	WWC	Site	01-Sep-94	0.427083333	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	08-Apr-92	0.59375	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	12-Dec-90	0.479166667	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	16-Nov-92	0.4375	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
EPA (1999) - Aquatic	WWC-09	WWC	Site	01-Sep-99	--	Extra (collocated with fish sample)	Dissolved	Lead	0.0005	0.070	7E-03
USGS electronic	6436198	WWC	Site	18-Mar-93	0.395833333	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
EPA (1999) - Aquatic	WWC-06	WWC	Site	01-Sep-99	--	Field	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436180	WWC	Site	24-May-94	0.465277778	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436180	WWC	Site	14-Feb-94	0.423611111	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436180	WWC	Site	31-May-90	0.395833333	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436180	WWC	Site	09-Sep-93	0.322916667	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	06-Jan-93	0.489583333	Gaging Station	DISSOLVED	Copper	0.005	0.080	6E-02
USGS electronic	6436180	WWC	Site	06-May-93	0.552083333	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
SDDENR electronic	460686	WWC	Site	13-Jan-98	1030	Water Quality Monitoring	Dissolved	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	03-Jun-99	0.583333333	Gaging Station	DISSOLVED	Lead	0.0005	0.070	7E-03
EPA (1999) - Aquatic	WWC-R-01 M	WWC	Ref	01-Sep-99	--	Field	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436198	WWC	Site	14-Oct-92	0.364583333	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	06-May-93	0.659722222	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	20-Jul-94	0.375	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	13-Sep-99	0.34375	Gaging Station	DISSOLVED	Lead	0.0005	0.070	7E-03
SDDENR electronic	460682	WWC	Site	25-Jun-97	1500	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02
EPA (1999) - Aquatic	SPC-R-12	OTHER	Ref	01-Sep-99	--	Field	Dissolved	Lead	0.001	0.070	1E-02
USGS electronic	6436198	WWC	Site	18-Aug-94	0.375	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	11-Mar-92	0.46875	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436198	WWC	Site	15-Apr-93	0.375	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436180	WWC	Site	27-Nov-91	0.375	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
USGS electronic	6436180	WWC	Site	02-Sep-92	0.489583333	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436180	WWC	Site	20-Dec-94	0.381944444	Gaging Station	DISSOLVED	Lead	0.01	0.070	1E-01
USGS electronic	6436198	WWC	Site	05-Jun-91	0.5	Gaging Station	DISSOLVED	Lead	0.005	0.070	7E-02
SDDENR electronic	460686	WWC	Site	21-Apr-98	1320	Water Quality Monitoring	Dissolved	Lead	0.001	0.070	1E-02

**APPENDIX F**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water - Site Stds**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Parameter	Adj Conc (ppm)	Site Std	HQchronic
SDDENR electronic	460123	WWC	Site	35234	1010	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460684	WWC	Site	36180	0.34375	Water Quality Monitoring Station	WAD	Cyanide	0.008	0.08	1E-01
SDDENR electronic	460685	WWC	Site	35990	715	Water Quality Monitoring	WAD	Cyanide	0.01	0.08	1E-01
SDDENR electronic	460123	WWC	Site	24-Apr-97	1225	Water Quality Monitoring	WAD	Cyanide	0.080	0.08	1.0E+00
SDDENR electronic	460123	WWC	Site	34808	830	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460684	WWC	Site	35927	1100	Water Quality Monitoring	WAD	Cyanide	0.019	0.08	2E-01
SDDENR electronic	460684	WWC	Site	35905	835	Water Quality Monitoring	WAD	Cyanide	0.022	0.08	3E-01
SDDENR electronic	460684	WWC	Site	35962	1120	Water Quality Monitoring	WAD	Cyanide	0.04	0.08	5E-01
SDDENR electronic	460122	WWC	Site	34073	1430	Water Quality Monitoring	WAD	Cyanide	0.03	0.08	4E-01
SDDENR electronic	460123	WWC	Site	34709	810	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460123	WWC	Site	34646	1110	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460123	WWC	Site	34988	1425	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460685	WWC	Site	36543	0.645833333	Water Quality Monitoring Station	WAD	Cyanide	0.066	0.08	8E-01
SDDENR electronic	460684	WWC	Site	36895	0.368055556	Water Quality Monitoring Station	WAD	Cyanide	0.021	0.08	3E-01
SDDENR electronic	460123	WWC	Site	34631	1210	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460123	WWC	Site	36591	0.5	Water Quality Monitoring Station	WAD	Cyanide	0.034	0.08	4E-01
SDDENR electronic	460123	WWC	Site	35275	1430	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460123	WWC	Site	35297	925	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460123	WWC	Site	35325	1000	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460123	WWC	Site	34589	950	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460123	WWC	Site	35361	905	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460682	WWC	Site	35962	1435	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460684	WWC	Site	36279	0.361111111	Water Quality Monitoring Station	WAD	Cyanide	0.007	0.08	9E-02
SDDENR electronic	460685	WWC	Site	35632	1425	Water Quality Monitoring	WAD	Cyanide	0.015	0.08	2E-01
SDDENR electronic	460684	WWC	Site	36642	0.350694444	Water Quality Monitoring Station	WAD	Cyanide	0.0025	0.08	3E-02
SDDENR electronic	460684	WWC	Site	35543	840	Water Quality Monitoring	WAD	Cyanide	0.06	0.08	8E-01
SDDENR electronic	460684	WWC	Site	35758	1100	Water Quality Monitoring	WAD	Cyanide	0.026	0.08	3E-01
SDDENR electronic	460684	WWC	Site	35844	1120	Water Quality Monitoring	WAD	Cyanide	0.029	0.08	4E-01
SDDENR electronic	460684	WWC	Site	35780	1200	Water Quality Monitoring	WAD	Cyanide	0.031	0.08	4E-01
SDDENR electronic	460684	WWC	Site	36025	1355	Water Quality Monitoring	WAD	Cyanide	0.016	0.08	2E-01
SDDENR electronic	460684	WWC	Site	34332	1030	Water Quality Monitoring	WAD	Cyanide	0.014	0.08	2E-01
SDDENR electronic	460685	WWC	Site	35185	1410	Water Quality Monitoring	WAD	Cyanide	0.02	0.08	3E-01
SDDENR electronic	460684	WWC	Site	35353	825	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460123	WWC	Site	35045	955	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460123	WWC	Site	35906	1420	Water Quality Monitoring	WAD	Cyanide	0.016	0.08	2E-01
SDDENR electronic	460123	WWC	Site	34969	950	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460122	WWC	Site	34562	950	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460123	WWC	Site	34898	825	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460122	WWC	Site	34417	1040	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460684	WWC	Site	25-Jun-97	1135	Water Quality Monitoring	WAD	Cyanide	0.080	0.08	1.0E+00
SDDENR electronic	460123	WWC	Site	34877	805	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460684	WWC	Site	36895	0.368055556	Water Quality Monitoring Station	WAD	Cyanide	0.021	0.08	3E-01
SDDENR electronic	460123	WWC	Site	36894	0.625	Water Quality Monitoring Station	WAD	Cyanide	0.034	0.08	4E-01
SDDENR electronic	460684	WWC	Site	36544	0.375	Water Quality Monitoring Station	WAD	Cyanide	0.042	0.08	5E-01
SDDENR electronic	460123	WWC	Site	34822	1010	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460123	WWC	Site	36179	0.604166667	Water Quality Monitoring Station	WAD	Cyanide	0.043	0.08	5E-01
SDDENR electronic	460684	WWC	Site	36213	0.5	Water Quality Monitoring Station	WAD	Cyanide	0.056	0.08	7E-01
SDDENR electronic	460684	WWC	Site	36592	0.354166667	Water Quality Monitoring Station	WAD	Cyanide	0.012	0.08	2E-01
SDDENR electronic	460123	WWC	Site	18-Jan-00	0.621527778	Water Quality Monitoring Station	WAD	Cyanide	0.092	0.08	1.2E+00
SDDENR electronic	460684	WWC	Site	36243	0.375	Water Quality Monitoring Station	WAD	Cyanide	0.029	0.08	4E-01
SDDENR electronic	460123	WWC	Site	35927	1025	Water Quality Monitoring	WAD	Cyanide	0.018	0.08	2E-01
SDDENR electronic	460122	WWC	Site	34752	1120	Water Quality Monitoring	WAD	Cyanide	0.016	0.08	2E-01
SDDENR electronic	460123	WWC	Site	36641	0.614583333	Water Quality Monitoring Station	WAD	Cyanide	0.0025	0.08	3E-02
SDDENR electronic	460685	WWC	Site	36894	0.642361111	Water Quality Monitoring Station	WAD	Cyanide	0.015	0.08	2E-01
SDDENR electronic	460122	WWC	Site	35780	1040	Water Quality Monitoring	WAD	Cyanide	0.026	0.08	3E-01
SDDENR electronic	460122	WWC	Site	35730	1355	Water Quality Monitoring	WAD	Cyanide	0.02	0.08	3E-01
SDDENR electronic	460123	WWC	Site	36752	0.440972222	Water Quality Monitoring Station	WAD	Cyanide	0.017	0.08	2E-01
SDDENR electronic	460685	WWC	Site	36081	0.645833333	Water Quality Monitoring Station	WAD	Cyanide	0.011	0.08	1E-01
SDDENR electronic	460123	WWC	Site	36509	0.524305556	Water Quality Monitoring Station	WAD	Cyanide	0.019	0.08	2E-01
SDDENR electronic	460685	WWC	Site	36458	0.354166667	Water Quality Monitoring Station	WAD	Cyanide	0.0025	0.08	3E-02
SDDENR electronic	460123	WWC	Site	36565	0.479166667	Water Quality Monitoring Station	WAD	Cyanide	0.021	0.08	3E-01
SDDENR electronic	460123	WWC	Site	36815	0.565972222	Water Quality Monitoring Station	WAD	Cyanide	0.012	0.08	2E-01
SDDENR electronic	460123	WWC	Site	35381	835	Water Quality Monitoring	WAD	Cyanide	0.01	0.08	1E-01

**APPENDIX F**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water - Site Stds**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Parameter	Adj Conc (ppm)	Site Std	HQchronic
SDDENR electronic	460684	WWC	Site	36362	0.565972222	Water Quality Monitoring Station	WAD	Cyanide	0.021	0.08	3E-01
SDDENR electronic	460684	WWC	Site	35731	1100	Water Quality Monitoring	WAD	Cyanide	0.022	0.08	3E-01
SDDENR electronic	460123	WWC	Site	36481	0.503472222	Water Quality Monitoring Station	WAD	Cyanide	0.021	0.08	3E-01
SDDENR electronic	460122	WWC	Site	35425	1110	Water Quality Monitoring	WAD	Cyanide	0.03	0.08	4E-01
SDDENR electronic	460123	WWC	Site	36118	0.46875	Water Quality Monitoring Station	WAD	Cyanide	0.021	0.08	3E-01
SDDENR electronic	460685	WWC	Site	36641	0.635416667	Water Quality Monitoring Station	WAD	Cyanide	0.0025	0.08	3E-02
SDDENR electronic	460123	WWC	Site	23-Feb-99	0.541666667	Water Quality Monitoring Station	WAD	Cyanide	0.076	0.08	9.5E-01
SDDENR electronic	460122	WWC	Site	34988	1340	Water Quality Monitoring	WAD	Cyanide	0.012	0.08	2E-01
SDDENR electronic	460122	WWC	Site	35632	1310	Water Quality Monitoring	WAD	Cyanide	0.012	0.08	2E-01
SDDENR electronic	460122	WWC	Site	35660	950	Water Quality Monitoring	WAD	Cyanide	0.012	0.08	2E-01
SDDENR electronic	460685	WWC	Site	24-Apr-97	1245	Water Quality Monitoring	WAD	Cyanide	0.090	0.08	1.1E+00
SDDENR electronic	460122	WWC	Site	34311	1120	Water Quality Monitoring	WAD	Cyanide	0.014	0.08	2E-01
SDDENR electronic	460123	WWC	Site	36242	0.552083333	Water Quality Monitoring Station	WAD	Cyanide	0.019	0.08	2E-01
SDDENR electronic	460122	WWC	Site	35080	940	Water Quality Monitoring	WAD	Cyanide	0.03	0.08	4E-01
SDDENR electronic	460122	WWC	Site	35844	955	Water Quality Monitoring	WAD	Cyanide	0.038	0.08	5E-01
SDDENR electronic	460122	WWC	Site	35471	1235	Water Quality Monitoring	WAD	Cyanide	0.037	0.08	5E-01
SDDENR electronic	460685	WWC	Site	35808	840	Water Quality Monitoring	WAD	Cyanide	0.0025	0.08	3E-02
SDDENR electronic	460123	WWC	Site	34939	1010	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460685	WWC	Site	35451	1530	Water Quality Monitoring	WAD	Cyanide	0.056	0.08	7E-01
SDDENR electronic	460122	WWC	Site	35696	955	Water Quality Monitoring	WAD	Cyanide	0.036	0.08	5E-01
SDDENR electronic	460122	WWC	Site	35451	1430	Water Quality Monitoring	WAD	Cyanide	0.034	0.08	4E-01
SDDENR electronic	460123	WWC	Site	37229	0.534722222	Water Quality Monitoring Station	WAD	Cyanide	0.0025	0.08	3E-02
SDDENR electronic	460122	WWC	Site	35150	1020	Water Quality Monitoring	WAD	Cyanide	0.04	0.08	5E-01
SDDENR electronic	460122	WWC	Site	35808	940	Water Quality Monitoring	WAD	Cyanide	0.044	0.08	6E-01
SDDENR electronic	460123	WWC	Site	34470	1015	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460684	WWC	Site	35184	830	Water Quality Monitoring	WAD	Cyanide	0.01	0.08	1E-01
SDDENR electronic	460123	WWC	Site	36844	0.541666667	Water Quality Monitoring Station	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460684	WWC	Site	35381	1145	Water Quality Monitoring	WAD	Cyanide	0.01	0.08	1E-01
SDDENR electronic	460685	WWC	Site	36361	0.642361111	Water Quality Monitoring Station	WAD	Cyanide	0.013	0.08	2E-01
SDDENR electronic	460685	WWC	Site	35730	1450	Water Quality Monitoring	WAD	Cyanide	0.013	0.08	2E-01
SDDENR electronic	460122	WWC	Site	35758	940	Water Quality Monitoring	WAD	Cyanide	0.029	0.08	4E-01
SDDENR electronic	460684	WWC	Site	14-Jan-98	1315	Water Quality Monitoring	WAD	Cyanide	0.098	0.08	1.2E+00
SDDENR electronic	460123	WWC	Site	35201	1110	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460685	WWC	Site	36179	0.618055556	Water Quality Monitoring Station	WAD	Cyanide	0.037	0.08	5E-01
SDDENR electronic	460123	WWC	Site	36025	1310	Water Quality Monitoring	WAD	Cyanide	0.03	0.08	4E-01
SDDENR electronic	460122	WWC	Site	35507	930	Water Quality Monitoring	WAD	Cyanide	0.059	0.08	7E-01
SDDENR electronic	460123	WWC	Site	35962	1040	Water Quality Monitoring	WAD	Cyanide	0.047	0.08	6E-01
SDDENR electronic	460123	WWC	Site	35990	740	Water Quality Monitoring	WAD	Cyanide	0.012	0.08	2E-01
SDDENR electronic	460684	WWC	Site	36306	0.524305556	Water Quality Monitoring Station	WAD	Cyanide	0.007	0.08	9E-02
SDDENR electronic	460122	WWC	Site	34631	1135	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460122	WWC	Site	35381	855	Water Quality Monitoring	WAD	Cyanide	0.01	0.08	1E-01
SDDENR electronic	460122	WWC	Site	34822	940	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460122	WWC	Site	34808	850	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460122	WWC	Site	35577	955	Water Quality Monitoring	WAD	Cyanide	0.0025	0.08	3E-02
SDDENR electronic	460122	WWC	Site	34772	1205	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460122	WWC	Site	34709	840	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460684	WWC	Site	34452	1300	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460122	WWC	Site	34646	1035	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460122	WWC	Site	34969	925	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460122	WWC	Site	34589	920	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460122	WWC	Site	36591	0.447916667	Water Quality Monitoring Station	WAD	Cyanide	0.044	0.08	6E-01
SDDENR electronic	460122	WWC	Site	34939	950	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460123	WWC	Site	35109	1205	Water Quality Monitoring	WAD	Cyanide	0.03	0.08	4E-01
SDDENR electronic	460123	WWC	Site	34417	1005	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460123	WWC	Site	35758	1005	Water Quality Monitoring	WAD	Cyanide	0.0025	0.08	3E-02
SDDENR electronic	460122	WWC	Site	34681	1230	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460122	WWC	Site	35234	945	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460122	WWC	Site	35606	845	Water Quality Monitoring	WAD	Cyanide	0.011	0.08	1E-01
SDDENR electronic	460122	WWC	Site	36214	0.493055556	Water Quality Monitoring Station	WAD	Cyanide	0.051	0.08	6E-01
SDDENR electronic	460122	WWC	Site	36894	0.482638889	Water Quality Monitoring Station	WAD	Cyanide	0.041	0.08	5E-01
SDDENR electronic	460122	WWC	Site	36509	0.479166667	Water Quality Monitoring Station	WAD	Cyanide	0.017	0.08	2E-01
SDDENR electronic	460122	WWC	Site	36242	0.479166667	Water Quality Monitoring Station	WAD	Cyanide	0.038	0.08	5E-01
SDDENR electronic	460122	WWC	Site	34877	830	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02

**APPENDIX F**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water - Site Stds**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Parameter	Adj Conc (ppm)	Site Std	HQchronic
SDDENR electronic	460122	WWC	Site	34898	845	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460122	WWC	Site	35275	1325	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460122	WWC	Site	35361	920	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460123	WWC	Site	35011	1130	Water Quality Monitoring	WAD	Cyanide	0.013	0.08	2E-01
SDDENR electronic	460123	WWC	Site	34772	1140	Water Quality Monitoring	WAD	Cyanide	0.013	0.08	2E-01
SDDENR electronic	460122	WWC	Site	35201	1140	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460122	WWC	Site	35109	1140	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460122	WWC	Site	35045	930	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460122	WWC	Site	35011	1200	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460123	WWC	Site	35471	1330	Water Quality Monitoring	WAD	Cyanide	0.069	0.08	9E-01
SDDENR electronic	460122	WWC	Site	35297	955	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460122	WWC	Site	34505	1000	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460123	WWC	Site	35577	1025	Water Quality Monitoring	WAD	Cyanide	0.0025	0.08	3E-02
SDDENR electronic	460686	WWC	Site	35990	855	Water Quality Monitoring	WAD	Cyanide	0.0025	0.08	3E-02
SDDENR electronic	460682	WWC	Site	36592	0.489583333	Water Quality Monitoring Station	WAD	Cyanide	0.008	0.08	1E-01
SDDENR electronic	460682	WWC	Site	36362	0.354166667	Water Quality Monitoring Station	WAD	Cyanide	0.0025	0.08	3E-02
SDDENR electronic	460682	WWC	Site	36243	0.555555556	Water Quality Monitoring Station	WAD	Cyanide	0.008	0.08	1E-01
SDDENR electronic	460682	WWC	Site	36642	0.552083333	Water Quality Monitoring Station	WAD	Cyanide	0.0025	0.08	3E-02
SDDENR electronic	460123	WWC	Site	35780	1105	Water Quality Monitoring	WAD	Cyanide	0.038	0.08	5E-01
SDDENR electronic	460682	WWC	Site	36459	0.534722222	Water Quality Monitoring Station	WAD	Cyanide	0.0025	0.08	3E-02
SDDENR electronic	460684	WWC	Site	36844	0.576388889	Water Quality Monitoring Station	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460682	WWC	Site	36060	0.652777778	Water Quality Monitoring Station	WAD	Cyanide	0.0025	0.08	3E-02
SDDENR electronic	460684	WWC	Site	36424	0.34375	Water Quality Monitoring Station	WAD	Cyanide	0.032	0.08	4E-01
SDDENR electronic	460122	WWC	Site	35962	1015	Water Quality Monitoring	WAD	Cyanide	0.037	0.08	5E-01
SDDENR electronic	460122	WWC	Site	35927	1000	Water Quality Monitoring	WAD	Cyanide	0.02	0.08	3E-01
SDDENR electronic	460122	WWC	Site	36025	1145	Water Quality Monitoring	WAD	Cyanide	0.017	0.08	2E-01
SDDENR electronic	460122	WWC	Site	35990	820	Water Quality Monitoring	WAD	Cyanide	0.017	0.08	2E-01
SDDENR electronic	460122	WWC	Site	35906	1355	Water Quality Monitoring	WAD	Cyanide	0.013	0.08	2E-01
SDDENR electronic	460122	WWC	Site	35325	930	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460123	WWC	Site	35808	915	Water Quality Monitoring	WAD	Cyanide	0.028	0.08	4E-01
SDDENR electronic	460122	WWC	Site	36361	0.465277778	Water Quality Monitoring Station	WAD	Cyanide	0.032	0.08	4E-01
SDDENR electronic	460123	WWC	Site	35451	1515	Water Quality Monitoring	WAD	Cyanide	0.057	0.08	7E-01
SDDENR electronic	460123	WWC	Site	35507	905	Water Quality Monitoring	WAD	Cyanide	0.055	0.08	7E-01
SDDENR electronic	460123	WWC	Site	34073	1350	Water Quality Monitoring	WAD	Cyanide	0.043	0.08	5E-01
SDDENR electronic	460123	WWC	Site	35696	1025	Water Quality Monitoring	WAD	Cyanide	0.042	0.08	5E-01
SDDENR electronic	460123	WWC	Site	34681	1210	Water Quality Monitoring	WAD	Cyanide	0.015	0.08	2E-01
SDDENR electronic	460686	WWC	Site	34709	915	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460123	WWC	Site	35632	1415	Water Quality Monitoring	WAD	Cyanide	0.015	0.08	2E-01
SDDENR electronic	460123	WWC	Site	35150	1045	Water Quality Monitoring	WAD	Cyanide	0.07	0.08	9E-01
SDDENR electronic	460123	WWC	Site	34311	1340	Water Quality Monitoring	WAD	Cyanide	0.023	0.08	3E-01
SDDENR electronic	460123	WWC	Site	35660	1015	Water Quality Monitoring	WAD	Cyanide	0.02	0.08	3E-01
SDDENR electronic	460123	WWC	Site	35606	820	Water Quality Monitoring	WAD	Cyanide	0.02	0.08	3E-01
SDDENR electronic	460123	WWC	Site	35425	1030	Water Quality Monitoring	WAD	Cyanide	0.02	0.08	3E-01
SDDENR electronic	460123	WWC	Site	35185	1340	Water Quality Monitoring	WAD	Cyanide	0.02	0.08	3E-01
SDDENR electronic	460123	WWC	Site	35080	905	Water Quality Monitoring	WAD	Cyanide	0.02	0.08	3E-01
SDDENR electronic	460123	WWC	Site	35730	1430	Water Quality Monitoring	WAD	Cyanide	0.019	0.08	2E-01
SDDENR electronic	460123	WWC	Site	35844	1020	Water Quality Monitoring	WAD	Cyanide	0.035	0.08	4E-01
SDDENR electronic	460684	WWC	Site	34877	1105	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460684	WWC	Site	35577	1105	Water Quality Monitoring	WAD	Cyanide	0.0025	0.08	3E-02
SDDENR electronic	460684	WWC	Site	35234	1105	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460684	WWC	Site	35201	1030	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460684	WWC	Site	35045	1050	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460684	WWC	Site	35011	1050	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460684	WWC	Site	34989	810	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460684	WWC	Site	35325	1050	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460684	WWC	Site	35150	1150	Water Quality Monitoring	WAD	Cyanide	0.04	0.08	5E-01
SDDENR electronic	460123	WWC	Site	34442	1430	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460684	WWC	Site	35991	750	Water Quality Monitoring	WAD	Cyanide	0.01	0.08	1E-01
SDDENR electronic	460684	WWC	Site	34802	1320	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460684	WWC	Site	34648	815	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460684	WWC	Site	34611	1305	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460684	WWC	Site	34589	1030	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460684	WWC	Site	34470	1120	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02

**APPENDIX F**  
**Detailed Risk Calculations for Aquatic Receptors from Surface Water - Site Stds**

Citation	Location ID	Reach ID	Site or Ref	Date	Time	Sample Type	Analysis Type	Parameter	Adj Conc (ppm)	Site Std	HQchronic
SDDENR electronic	460122	WWC	Site	35185	1315	Water Quality Monitoring	WAD	Cyanide	0.01	0.08	1E-01
SDDENR electronic	460684	WWC	Site	34941	830	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460684	WWC	Site	35452	830	Water Quality Monitoring	WAD	Cyanide	0.011	0.08	1E-01
SDDENR electronic	460684	WWC	Site	35429	910	Water Quality Monitoring	WAD	Cyanide	0.02	0.08	3E-01
SDDENR electronic	460684	WWC	Site	35074	835	Water Quality Monitoring	WAD	Cyanide	0.02	0.08	3E-01
SDDENR electronic	460684	WWC	Site	34752	1000	Water Quality Monitoring	WAD	Cyanide	0.02	0.08	3E-01
SDDENR electronic	460684	WWC	Site	34772	1200	Water Quality Monitoring	WAD	Cyanide	0.042	0.08	5E-01
SDDENR electronic	460684	WWC	Site	34703	1320	Water Quality Monitoring	WAD	Cyanide	0.016	0.08	2E-01
SDDENR electronic	460684	WWC	Site	35696	1100	Water Quality Monitoring	WAD	Cyanide	0.045	0.08	6E-01
SDDENR electronic	460684	WWC	Site	35297	810	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460684	WWC	Site	35109	1315	Water Quality Monitoring	WAD	Cyanide	0.012	0.08	2E-01
SDDENR electronic	460684	WWC	Site	18-Mar-97	1215	Water Quality Monitoring	WAD	Cyanide	0.081	0.08	1.0E+00
SDDENR electronic	460684	WWC	Site	34969	1025	Water Quality Monitoring	WAD	Cyanide	0.011	0.08	1E-01
SDDENR electronic	460684	WWC	Site	34416	1020	Water Quality Monitoring	WAD	Cyanide	0.011	0.08	1E-01
SDDENR electronic	460123	WWC	Site	36661	0.503472222	Water Quality Monitoring Station	WAD	Cyanide	0.0025	0.08	3E-02
SDDENR electronic	460123	WWC	Site	36306	0.5	Water Quality Monitoring Station	WAD	Cyanide	0.012	0.08	2E-01
SDDENR electronic	460685	WWC	Site	35906	1440	Water Quality Monitoring	WAD	Cyanide	0.015	0.08	2E-01
SDDENR electronic	460684	WWC	Site	34681	1140	Water Quality Monitoring	WAD	Cyanide	0.019	0.08	2E-01
SDDENR electronic	460684	WWC	Site	34822	1100	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460684	WWC	Site	35633	825	Water Quality Monitoring	WAD	Cyanide	0.013	0.08	2E-01
SDDENR electronic	460122	WWC	Site	36423	0.46875	Water Quality Monitoring Station	WAD	Cyanide	0.06	0.08	8E-01
SDDENR electronic	460123	WWC	Site	34752	1035	Water Quality Monitoring	WAD	Cyanide	0.016	0.08	2E-01
SDDENR electronic	460122	WWC	Site	36543	0.506944444	Water Quality Monitoring Station	WAD	Cyanide	0.051	0.08	6E-01
SDDENR electronic	460122	WWC	Site	34442	1355	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460684	WWC	Site	36145	0.548611111	Water Quality Monitoring Station	WAD	Cyanide	0.017	0.08	2E-01
SDDENR electronic	460122	WWC	Site	36641	0.489583333	Water Quality Monitoring Station	WAD	Cyanide	0.008	0.08	1E-01
SDDENR electronic	460122	WWC	Site	36458	0.503472222	Water Quality Monitoring Station	WAD	Cyanide	0.018	0.08	2E-01
SDDENR electronic	460682	WWC	Site	36544	0.586805556	Water Quality Monitoring Station	WAD	Cyanide	0.009	0.08	1E-01
SDDENR electronic	460122	WWC	Site	36788	0.486111111	Water Quality Monitoring Station	WAD	Cyanide	0.0025	0.08	3E-02
SDDENR electronic	460682	WWC	Site	36564	0.638888889	Water Quality Monitoring Station	WAD	Cyanide	0.009	0.08	1E-01
SDDENR electronic	460122	WWC	Site	35544	1155	Water Quality Monitoring	WAD	Cyanide	0.07	0.08	9E-01
SDDENR electronic	460122	WWC	Site	36144	0.576388889	Water Quality Monitoring Station	WAD	Cyanide	0.029	0.08	4E-01
SDDENR electronic	460682	WWC	Site	35927	1245	Water Quality Monitoring	WAD	Cyanide	0.008	0.08	1E-01
SDDENR electronic	460682	WWC	Site	36025	1515	Water Quality Monitoring	WAD	Cyanide	0.0025	0.08	3E-02
SDDENR electronic	460682	WWC	Site	35991	1125	Water Quality Monitoring	WAD	Cyanide	0.0025	0.08	3E-02
SDDENR electronic	460122	WWC	Site	36375	0.489583333	Water Quality Monitoring Station	WAD	Cyanide	0.033	0.08	4E-01
SDDENR electronic	460684	WWC	Site	35660	1100	Water Quality Monitoring	WAD	Cyanide	0.022	0.08	3E-01
SDDENR electronic	460122	WWC	Site	36081	0.565972222	Water Quality Monitoring Station	WAD	Cyanide	0.008	0.08	1E-01
SDDENR electronic	460685	WWC	Site	34709	750	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460684	WWC	Site	34899	1255	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460682	WWC	Site	36145	0.475694444	Water Quality Monitoring Station	WAD	Cyanide	0.012	0.08	2E-01
SDDENR electronic	460685	WWC	Site	35361	845	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460685	WWC	Site	35275	1445	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460685	WWC	Site	35080	800	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460685	WWC	Site	34988	1445	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460122	WWC	Site	36179	0.46875	Water Quality Monitoring Station	WAD	Cyanide	0.057	0.08	7E-01
SDDENR electronic	460685	WWC	Site	34808	810	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460122	WWC	Site	36305	0.447916667	Water Quality Monitoring Station	WAD	Cyanide	0.016	0.08	2E-01
SDDENR electronic	460685	WWC	Site	34631	1245	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460685	WWC	Site	34442	1450	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02
SDDENR electronic	460123	WWC	Site	34562	1020	Water Quality Monitoring	WAD	Cyanide	0.01	0.08	1E-01
SDDENR electronic	460682	WWC	Site	36115	0.534722222	Water Quality Monitoring Station	WAD	Cyanide	0.012	0.08	2E-01
SDDENR electronic	460682	WWC	Site	36375	0.333333333	Water Quality Monitoring Station	WAD	Cyanide	0.0025	0.08	3E-02
SDDENR electronic	460682	WWC	Site	36180	0.534722222	Water Quality Monitoring Station	WAD	Cyanide	0.01	0.08	1E-01
SDDENR electronic	460682	WWC	Site	36213	0.361111111	Water Quality Monitoring Station	WAD	Cyanide	0.007	0.08	9E-02
SDDENR electronic	460685	WWC	Site	34898	800	Water Quality Monitoring	WAD	Cyanide	0.005	0.08	6E-02

## **APPENDIX G**

### **DETAILED RISK CALCULATIONS FOR BENTHIC MACROINVERTEBRATES FROM DIRECT CONTACT WITH SEDIMENT**

**Appendix G**  
**Detailed Risk Calculations for Benthic Macroinvertebrates**  
**from Direct Contact with Sediment**

*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*

Monitoring Station	Analyte	Sediment Concentration (mg/kg)	Sediment Toxicity Benchmarks (mg/kg)		Hazard Quotients (HQs)	
		Mean	Low	High	Low	High
<b>WWC-R-01</b> WWC Ref  <i>WWC upstream Homestake Gold Mine</i>	Arsenic	20	9.8	33	2E+00	6E-01
	Cadmium	0.20	1.0	5.0	2E-01	4E-02
	Copper	8	32	149	3E-01	5E-02
	Lead	11	36	128	3E-01	9E-02
	Manganese	228	631	4,460	4E-01	5E-02
	Mercury	0.08	0.18	1.06	4E-01	8E-02
	Nickel	4	23	49	2E-01	8E-02
	Zinc	21	121	459	2E-01	5E-02
<b>WWC-02</b> WWC Site  <i>WWC upstream confluence Gold Run Creek</i>	Arsenic	235	9.8	33	2E+01	7E+00
	Cadmium	1.10	1.0	5.0	1E+00	2E-01
	Copper	43	32	149	1E+00	3E-01
	Lead	15	36	128	4E-01	1E-01
	Manganese	1,130	631	4,460	2E+00	3E-01
	Mercury	0.19	0.18	1.06	1E+00	2E-01
	Nickel	33	23	49	1E+00	7E-01
	Zinc	139	121	459	1E+00	3E-01
<b>WWC-03</b> WWC Site  <i>WWC downstream confluence Gold Run Creek</i>	Arsenic	484	9.8	33	5E+01	1E+01
	Cadmium	1.80	1.0	5.0	2E+00	4E-01
	Copper	93	32	149	3E+00	6E-01
	Lead	245	36	128	7E+00	2E+00
	Manganese	1,100	631	4,460	2E+00	2E-01
	Mercury	0.34	0.18	1.06	2E+00	3E-01
	Nickel	39	23	49	2E+00	8E-01
	Zinc	216	121	459	2E+00	5E-01
<b>WWC-04</b> WWC Site  <i>WWC at Crook City downstream of bridge</i>	Arsenic	608	9.8	33	6E+01	2E+01
	Cadmium	1.40	1.0	5.0	1E+00	3E-01
	Copper	109	32	149	3E+00	7E-01
	Lead	45	36	128	1E+00	4E-01
	Manganese	902	631	4,460	1E+00	2E-01
	Mercury	0.27	0.18	1.06	2E+00	3E-01
	Nickel	32	23	49	1E+00	7E-01
	Zinc	133	121	459	1E+00	3E-01
<b>WWC-05</b> WWC Site  <i>WWC at Bighorn Road upstream of bridge</i>	Arsenic	1150	9.8	33	1E+02	3E+01
	Cadmium	1.10	1.0	5.0	1E+00	2E-01
	Copper	55	32	149	2E+00	4E-01
	Lead	27	36	128	8E-01	2E-01
	Manganese	862	631	4,460	1E+00	2E-01
	Mercury	0.65	0.18	1.06	4E+00	6E-01
	Nickel	22	23	49	1E+00	5E-01
	Zinc	101	121	459	8E-01	2E-01
<b>WWC-06</b> WWC Site  <i>WWC at Berger Seep</i>	Arsenic	1230	9.8	33	1E+02	4E+01
	Cadmium	1.00	1.0	5.0	1E+00	2E-01
	Copper	49	32	149	2E+00	3E-01
	Lead	20	36	128	5E-01	2E-01
	Manganese	772	631	4,460	1E+00	2E-01
	Mercury	0.36	0.18	1.06	2E+00	3E-01
	Nickel	26	23	49	1E+00	5E-01
	Zinc	125	121	459	1E+00	3E-01

**Appendix G**  
**Detailed Risk Calculations for Benthic Macroinvertebrates**  
**from Direct Contact with Sediment**

*Ecological Risk Assessment*  
*Whitewood Creek Site, Lead, South Dakota*

Monitoring Station	Analyte	Sediment Concentration (mg/kg)	Sediment Toxicity Benchmarks (mg/kg)		Hazard Quotients (HQs)	
		Mean	Low	High	Low	High
<b>WWC-07</b> WWC Site  <i>WWC at 194th Street</i>	Arsenic	607	9.8	33	<b>6E+01</b>	<b>2E+01</b>
	Cadmium	0.68	1.0	5.0	7E-01	1E-01
	Copper	33	32	149	1E+00	2E-01
	Lead	15	36	128	4E-01	1E-01
	Manganese	610	631	4,460	1E+00	1E-01
	Mercury	0.26	0.18	1.06	1E+00	2E-01
	Nickel	20	23	49	9E-01	4E-01
	Zinc	73	121	459	6E-01	2E-01
<b>WWC-08</b> WWC Site  <i>WWC at Siphon Area</i>	Arsenic	789	9.8	33	<b>8E+01</b>	<b>2E+01</b>
	Cadmium	1.02	1.0	5.0	1E+00	2E-01
	Copper	35	32	149	1E+00	2E-01
	Lead	13	36	128	4E-01	1E-01
	Manganese	833	631	4,460	1E+00	2E-01
	Mercury	0.31	0.18	1.06	<b>2E+00</b>	3E-01
	Nickel	19	23	49	8E-01	4E-01
	Zinc	64	121	459	5E-01	1E-01
<b>WWC-09</b> WWC Site  <i>WWC at Keiry Property</i>	Arsenic	565	9.8	33	<b>6E+01</b>	<b>2E+01</b>
	Cadmium	1.30	1.0	5.0	1E+00	3E-01
	Copper	36	32	149	1E+00	2E-01
	Lead	17	36	128	5E-01	1E-01
	Manganese	735	631	4,460	1E+00	2E-01
	Mercury	0.28	0.18	1.06	<b>2E+00</b>	3E-01
	Nickel	25	23	49	1E+00	5E-01
	Zinc	94	121	459	8E-01	2E-01
<b>BFR-R-10</b> BFRu Ref  <i>BFR 1 mi. upstream confluence WWC</i>	Arsenic	14	9.8	33	1E+00	4E-01
	Cadmium	1.90	1.0	5.0	<b>2E+00</b>	4E-01
	Copper	21	32	149	7E-01	1E-01
	Lead	12	36	128	3E-01	9E-02
	Manganese	623	631	4,460	1E+00	1E-01
	Mercury	0.04	0.18	1.06	2E-01	4E-02
	Nickel	26	23	49	1E+00	5E-01
	Zinc	78	121	459	6E-01	2E-01
<b>BFR-11</b> BFRd Site  <i>BFR 1 mi. downstream confluence WWC</i>	Arsenic	1400	9.8	33	<b>1E+02</b>	<b>4E+01</b>
	Cadmium	1.30	1.0	5.0	1E+00	3E-01
	Copper	31	32	149	1E+00	2E-01
	Lead	20	36	128	6E-01	2E-01
	Manganese	844	631	4,460	1E+00	2E-01
	Mercury	0.17	0.18	1.06	9E-01	2E-01
	Nickel	22	23	49	1E+00	4E-01
	Zinc	77	121	459	6E-01	2E-01
<b>SPC-R-12</b> OTHER Ref  <i>Spearfish Creek 4 mi. upstream confluence Redwater River</i>	Arsenic	14	9.8	33	1E+00	4E-01
	Cadmium	0.37	1.0	5.0	4E-01	7E-02
	Copper	7	32	149	2E-01	5E-02
	Lead	14	36	128	4E-01	1E-01
	Manganese	194	631	4,460	3E-01	4E-02
	Mercury	0.04	0.18	1.06	2E-01	4E-02
	Nickel	5	23	49	2E-01	9E-02
	Zinc	25	121	459	2E-01	5E-02

Non-detects were evaluated at 1/2 of the detection limit.

Hazard Quotients (HQs) greater than 1E+00 are in **boldface type**.

## **APPENDIX H**

### **DETAILED RISK CALCULATIONS FOR TERRESTRIAL PLANTS FROM DIRECT CONTACT WITH SURFACE SOIL**

## APPENDIX H

### Detailed Risk Calculations for Terrestrial Plants from Direct Contact with Surface Soil

Citation	Location ID	Sample ID	Reach ID	Site or Ref	Analysis Type	Parameter	Conc (mg/kg)	Selected Phytotoxicity Benchmark (mg/kg dw)	Vegetation HQ
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Aluminum	9540	50	2E+02
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Aluminum	3485	50	7E+01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Aluminum	3200	50	6E+01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Aluminum	2500	50	5E+01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Aluminum	2900	50	6E+01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Aluminum	2300	50	5E+01
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Aluminum	3806.67	50	8E+01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Aluminum	3700	50	7E+01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Aluminum	3700	50	7E+01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Aluminum	11000	50	2E+02
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Aluminum	11000	50	2E+02
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Aluminum	6005	50	1E+02
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Aluminum	4500	50	9E+01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Aluminum	7400	50	1E+02
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Aluminum	19000	50	4E+02
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Aluminum	9800	50	2E+02
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Aluminum	6710	50	1E+02
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Aluminum	8905	50	2E+02
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Aluminum	3900	50	8E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Aluminum	8600	50	2E+02
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Aluminum	6000	50	1E+02
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Aluminum	10000	50	2E+02
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Aluminum	14000	50	3E+02
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Aluminum	5955	50	1E+02
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Aluminum	6400	50	1E+02
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Aluminum	7200	50	1E+02
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Aluminum	10000	50	2E+02
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Aluminum	10350	50	2E+02
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Aluminum	11000	50	2E+02
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Antimony	0.405	5	8E-02
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Antimony	3.6425	5	7E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Antimony	3.3	5	7E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Antimony	6.6	5	1E+00

## APPENDIX H

### Detailed Risk Calculations for Terrestrial Plants from Direct Contact with Surface Soil

Citation	Location ID	Sample ID	Reach ID	Site or Ref	Analysis Type	Parameter	Conc (mg/kg)	Selected Phytotoxicity Benchmark (mg/kg dw)	Vegetation HQ
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Antimony	3.45	5	7E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Antimony	6.9	5	1E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Antimony	2.83333	5	6E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Antimony	9	5	2E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Antimony	3.25	5	7E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Antimony	4.3	5	9E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Antimony	8	5	2E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Antimony	6.45	5	1E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Antimony	3.4	5	7E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Antimony	3.4	5	7E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Antimony	16	5	3E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Antimony	7	5	1E+00
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Antimony	0.37	5	7E-02
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Antimony	0.4	5	8E-02
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Antimony	3.3	5	7E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Antimony	9	5	2E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Antimony	7.3	5	1E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Antimony	10	5	2E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Antimony	7	5	1E+00
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Antimony	1.005	5	2E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Antimony	3	5	6E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Antimony	3.85	5	8E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Antimony	3	5	6E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Antimony	4	5	8E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Antimony	4	5	8E-01
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Arsenic	13.4	10	1E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Arsenic	15.05	10	2E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Arsenic	0.2	10	2E-02
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Arsenic	0.4	10	4E-02
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Arsenic	22	10	2E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Arsenic	0.5	10	5E-02
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Arsenic	1466.67	10	1E+02
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Arsenic	3600	10	4E+02

## APPENDIX H

### Detailed Risk Calculations for Terrestrial Plants from Direct Contact with Surface Soil

Citation	Location ID	Sample ID	Reach ID	Site or Ref	Analysis Type	Parameter	Conc (mg/kg)	Selected Phytotoxicity Benchmark (mg/kg dw)	Vegetation HQ
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Arsenic	1000	10	1E+02
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Arsenic	1500	10	2E+02
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Arsenic	3500	10	4E+02
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Arsenic	2550	10	3E+02
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Arsenic	2700	10	3E+02
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Arsenic	1900	10	2E+02
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Arsenic	8600	10	9E+02
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Arsenic	3240	10	3E+02
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Arsenic	1400	10	1E+02
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Arsenic	2625	10	3E+02
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Arsenic	3400	10	3E+02
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Arsenic	2800	10	3E+02
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Arsenic	960	10	1E+02
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Arsenic	2500	10	3E+02
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Arsenic	920	10	9E+01
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Arsenic	1230	10	1E+02
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Arsenic	0.3	10	3E-02
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Arsenic	0.15	10	2E-02
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Arsenic	0.3	10	3E-02
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Arsenic	0.25	10	3E-02
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Arsenic	0.25	10	3E-02
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Barium	171	500	3E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Barium	108.5	500	2E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Barium	120	500	2E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Barium	110	500	2E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Barium	120	500	2E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Barium	110	500	2E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Barium	119.867	500	2E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Barium	130	500	3E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Barium	130	500	3E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Barium	300	500	6E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Barium	170	500	3E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Barium	121.5	500	2E-01

## APPENDIX H

### Detailed Risk Calculations for Terrestrial Plants from Direct Contact with Surface Soil

Citation	Location ID	Sample ID	Reach ID	Site or Ref	Analysis Type	Parameter	Conc (mg/kg)	Selected Phytotoxicity Benchmark (mg/kg dw)	Vegetation HQ
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Barium	93	500	2E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Barium	200	500	4E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Barium	210	500	4E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Barium	180	500	4E-01
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Barium	137	500	3E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Barium	147.5	500	3E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Barium	90	500	2E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Barium	150	500	3E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Barium	120	500	2E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Barium	160	500	3E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Barium	190	500	4E-01
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Barium	143	500	3E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Barium	140	500	3E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Barium	135	500	3E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Barium	310	500	6E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Barium	300	500	6E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Barium	240	500	5E-01
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Boron	15.4	0.5	3E+01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Boron	8.1	0.5	2E+01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Boron	9	0.5	2E+01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Boron	8	0.5	2E+01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Boron	8	0.5	2E+01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Boron	8	0.5	2E+01
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Boron	5.53333	0.5	1E+01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Boron	14	0.5	3E+01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Boron	8	0.5	2E+01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Boron	12	0.5	2E+01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Boron	11	0.5	2E+01
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Boron	7.5	0.5	2E+01
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Boron	9	0.5	2E+01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Boron	8	0.5	2E+01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Boron	11	0.5	2E+01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Boron	9	0.5	2E+01

## APPENDIX H

### Detailed Risk Calculations for Terrestrial Plants from Direct Contact with Surface Soil

Citation	Location ID	Sample ID	Reach ID	Site or Ref	Analysis Type	Parameter	Conc (mg/kg)	Selected Phytotoxicity Benchmark (mg/kg dw)	Vegetation HQ
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Boron	6.8	0.5	1E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Boron	7.4	0.5	1E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Boron	9	0.5	2E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Boron	6	0.5	1E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Boron	8	0.5	2E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Boron	8	0.5	2E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Boron	7	0.5	1E+01
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Boron	5.25	0.5	1E+01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Boron	10	0.5	2E+01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Boron	4.5	0.5	9E+00
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Boron	1.5	0.5	3E+00
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Boron	2.25	0.5	5E+00
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Boron	5	0.5	1E+01
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Chromium	12.3	1	1E+01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Chromium	6.45	1	6E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Chromium	6	1	6E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Chromium	4	1	4E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Chromium	5	1	5E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Chromium	4	1	4E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Chromium	10	1	1E+01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Chromium	8	1	8E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Chromium	10	1	1E+01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Chromium	22	1	2E+01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Chromium	20	1	2E+01
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Chromium	11.05	1	1E+01
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Chromium	7	1	7E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Chromium	14	1	1E+01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Chromium	23	1	2E+01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Chromium	17	1	2E+01
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Chromium	12.1	1	1E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Chromium	13.9	1	1E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Chromium	7	1	7E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Chromium	13	1	1E+01

## APPENDIX H

### Detailed Risk Calculations for Terrestrial Plants from Direct Contact with Surface Soil

Citation	Location ID	Sample ID	Reach ID	Site or Ref	Analysis Type	Parameter	Conc (mg/kg)	Selected Phytotoxicity Benchmark (mg/kg dw)	Vegetation HQ
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Chromium	10	1	1E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Chromium	15	1	2E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Chromium	18	1	2E+01
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Chromium	11.65	1	1E+01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Chromium	8	1	8E+00
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Chromium	9	1	9E+00
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Chromium	11	1	1E+01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Chromium	14.5	1	1E+01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Chromium	12	1	1E+01
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Copper	25.9	60	4E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Copper	7.9	60	1E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Copper	6	60	1E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Copper	4	60	7E-02
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Copper	6	60	1E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Copper	5	60	8E-02
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Copper	42.9333	60	7E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Copper	37	60	6E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Copper	29	60	5E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Copper	98	60	2E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Copper	70	60	1E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Copper	63.5	60	1E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Copper	39	60	7E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Copper	68	60	1E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Copper	140	60	2E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Copper	75	60	1E+00
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Copper	45.1	60	8E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Copper	54.4	60	9E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Copper	34	60	6E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Copper	50	60	8E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Copper	30	60	5E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Copper	65	60	1E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Copper	56	60	9E-01
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Copper	42	60	7E-01

## APPENDIX H

### Detailed Risk Calculations for Terrestrial Plants from Direct Contact with Surface Soil

Citation	Location ID	Sample ID	Reach ID	Site or Ref	Analysis Type	Parameter	Conc (mg/kg)	Selected Phytotoxicity Benchmark (mg/kg dw)	Vegetation HQ
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Copper	11	60	2E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Copper	9	60	2E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Copper	14	60	2E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Copper	13.5	60	2E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Copper	14	60	2E-01
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Iron	20000	NA	NC
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Iron	6675	NA	NC
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Iron	6200	NA	NC
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Iron	5200	NA	NC
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Iron	6200	NA	NC
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Iron	5000	NA	NC
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Iron	44233.3	NA	NC
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Iron	43000	NA	NC
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Iron	49000	NA	NC
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Iron	53000	NA	NC
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Iron	82000	NA	NC
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Iron	69500	NA	NC
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Iron	4900	NA	NC
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Iron	48000	NA	NC
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Iron	120000	NA	NC
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Iron	74000	NA	NC
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Iron	54100	NA	NC
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Iron	85850	NA	NC
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Iron	54000	NA	NC
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Iron	79000	NA	NC
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Iron	45000	NA	NC
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Iron	8200	NA	NC
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Iron	83000	NA	NC
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Iron	53450	NA	NC
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Iron	12000	NA	NC
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Iron	8150	NA	NC
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Iron	11000	NA	NC
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Iron	9550	NA	NC

## APPENDIX H

### Detailed Risk Calculations for Terrestrial Plants from Direct Contact with Surface Soil

Citation	Location ID	Sample ID	Reach ID	Site or Ref	Analysis Type	Parameter	Conc (mg/kg)	Selected Phytotoxicity Benchmark (mg/kg dw)	Vegetation HQ
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Iron	12000	NA	NC
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Lead	15.7	50	3E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Lead	23.45	50	5E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Lead	22	50	4E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Lead	23	50	5E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Lead	28	50	6E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Lead	20	50	4E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Lead	22.9667	50	5E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Lead	24	50	5E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Lead	20	50	4E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Lead	58	50	1E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Lead	30	50	6E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Lead	19.95	50	4E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Lead	10	50	2E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Lead	32	50	6E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Lead	38	50	8E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Lead	30	50	6E-01
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Lead	18.3	50	4E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Lead	17.6	50	4E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Lead	10	50	2E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Lead	10	50	2E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Lead	10	50	2E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Lead	10	50	2E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Lead	20	50	4E-01
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Lead	23.55	50	5E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Lead	20	50	4E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Lead	10	50	2E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Lead	20	50	4E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Lead	20	50	4E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Lead	20	50	4E-01
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Manganese	639	500	1E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Manganese	295.5	500	6E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Manganese	290	500	6E-01

## APPENDIX H

### Detailed Risk Calculations for Terrestrial Plants from Direct Contact with Surface Soil

Citation	Location ID	Sample ID	Reach ID	Site or Ref	Analysis Type	Parameter	Conc (mg/kg)	Selected Phytotoxicity Benchmark (mg/kg dw)	Vegetation HQ
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Manganese	250	500	5E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Manganese	280	500	6E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Manganese	240	500	5E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Manganese	922.333	500	2E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Manganese	970	500	2E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Manganese	700	500	1E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Manganese	1800	500	4E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Manganese	1800	500	4E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Manganese	592	500	1E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Manganese	1100	500	2E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Manganese	1400	500	3E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Manganese	990	500	2E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Manganese	1800	500	4E+00
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Manganese	998	500	2E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Manganese	1290	500	3E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Manganese	730	500	1E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Manganese	1200	500	2E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Manganese	920	500	2E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Manganese	980	500	2E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Manganese	2800	500	6E+00
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Manganese	961	500	2E+00
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Manganese	440	500	9E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Manganese	145	500	3E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Manganese	430	500	9E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Manganese	280	500	6E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Manganese	490	500	1E+00
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Mercury	0.03	5	6E-03
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Mercury	1.09	5	2E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Mercury	0.005	5	1E-03
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Mercury	0.005	5	1E-03
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Mercury	0.005	5	1E-03
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Mercury	0.01	5	2E-03
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Mercury	0.28667	5	6E-02

## APPENDIX H

### Detailed Risk Calculations for Terrestrial Plants from Direct Contact with Surface Soil

Citation	Location ID	Sample ID	Reach ID	Site or Ref	Analysis Type	Parameter	Conc (mg/kg)	Selected Phytotoxicity Benchmark (mg/kg dw)	Vegetation HQ
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Mercury	0.5	5	1E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Mercury	0.3	5	6E-02
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Mercury	1	5	2E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Mercury	1	5	2E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Mercury	0.21	5	4E-02
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Mercury	2	5	4E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Mercury	2	5	4E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Mercury	2	5	4E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Mercury	0.9	5	2E-01
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Mercury	0.34	5	7E-02
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Mercury	0.915	5	2E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Mercury	1	5	2E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Mercury	1	5	2E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Mercury	0.01	5	2E-03
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Mercury	1	5	2E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Mercury	1	5	2E-01
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Mercury	0.345	5	7E-02
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Mercury	1	5	2E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Mercury	0.005	5	1E-03
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Mercury	0.01	5	2E-03
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Mercury	0.005	5	1E-03
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Mercury	0.005	5	1E-03
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Molybdenum	3.4	2	2E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Molybdenum	0.58	2	3E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Molybdenum	0.4	2	2E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Molybdenum	0.4	2	2E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Molybdenum	0.8	2	4E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Molybdenum	0.7	2	4E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Molybdenum	2.06667	2	1E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Molybdenum	1	2	5E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Molybdenum	2	2	1E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Molybdenum	1	2	5E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Molybdenum	1	2	5E-01

## APPENDIX H

### Detailed Risk Calculations for Terrestrial Plants from Direct Contact with Surface Soil

Citation	Location ID	Sample ID	Reach ID	Site or Ref	Analysis Type	Parameter	Conc (mg/kg)	Selected Phytotoxicity Benchmark (mg/kg dw)	Vegetation HQ
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Molybdenum	3.65	2	2E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Molybdenum	0.4	2	2E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Molybdenum	0.4	2	2E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Molybdenum	0.45	2	2E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Molybdenum	0.4	2	2E-01
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Molybdenum	1.8	2	9E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Molybdenum	1.4	2	7E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Molybdenum	0.4	2	2E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Molybdenum	0.45	2	2E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Molybdenum	1	2	5E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Molybdenum	0.4	2	2E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Molybdenum	0.4	2	2E-01
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Molybdenum	1.9	2	1E+00
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Molybdenum	0.55	2	3E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Molybdenum	0.45	2	2E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Molybdenum	0.5	2	3E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Molybdenum	0.45	2	2E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Molybdenum	0.45	2	2E-01
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Nickel	27.9	30	9E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Nickel	7.4	30	2E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Nickel	8	30	3E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Nickel	6	30	2E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Nickel	5	30	2E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Nickel	6	30	2E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Nickel	21.3	30	7E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Nickel	18	30	6E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Nickel	19	30	6E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Nickel	42	30	1E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Nickel	22	30	7E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Nickel	14.1	30	5E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Nickel	8	30	3E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Nickel	28	30	9E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Nickel	26	30	9E-01

## APPENDIX H

### Detailed Risk Calculations for Terrestrial Plants from Direct Contact with Surface Soil

Citation	Location ID	Sample ID	Reach ID	Site or Ref	Analysis Type	Parameter	Conc (mg/kg)	Selected Phytotoxicity Benchmark (mg/kg dw)	Vegetation HQ
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Nickel	22	30	7E-01
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Nickel	21.7	30	7E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Nickel	19.15	30	6E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Nickel	8	30	3E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Nickel	7	30	2E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Nickel	16	30	5E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Nickel	10	30	3E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Nickel	16	30	5E-01
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Nickel	19.8	30	7E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Nickel	7	30	2E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Nickel	9.5	30	3E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Nickel	13	30	4E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Nickel	9.5	30	3E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Nickel	13	30	4E-01
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Silver	0.07	2	4E-02
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Silver	0.3325	2	2E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Silver	0.3	2	2E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Silver	0.6	2	3E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Silver	0.3	2	2E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Silver	0.6	2	3E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Silver	0.78333	2	4E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Silver	1	2	5E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Silver	1	2	5E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Silver	2	2	1E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Silver	2	2	1E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Silver	0.66	2	3E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Silver	1	2	5E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Silver	2	2	1E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Silver	3	2	2E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Silver	2	2	1E+00
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Silver	0.16	2	8E-02
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Silver	0.43	2	2E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Silver	2	2	1E+00

## APPENDIX H

### Detailed Risk Calculations for Terrestrial Plants from Direct Contact with Surface Soil

Citation	Location ID	Sample ID	Reach ID	Site or Ref	Analysis Type	Parameter	Conc (mg/kg)	Selected Phytotoxicity Benchmark (mg/kg dw)	Vegetation HQ
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Silver	1	2	5E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Silver	0.7	2	4E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Silver	1	2	5E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Silver	2	2	1E+00
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Silver	0.18	2	9E-02
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Silver	0.4	2	2E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Silver	0.3	2	2E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Silver	0.35	2	2E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Silver	0.325	2	2E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Silver	0.35	2	2E-01
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Thallium	0.405	1	4E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Thallium	0.4425	1	4E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Thallium	0.2	1	2E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Thallium	0.2	1	2E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Thallium	0.25	1	3E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Thallium	0.5	1	5E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Thallium	0.71667	1	7E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Thallium	0.7	1	7E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Thallium	0.7	1	7E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Thallium	2	1	2E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Thallium	0.9	1	9E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Thallium	0.57	1	6E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Thallium	0.6	1	6E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Thallium	2	1	2E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Thallium	1	1	1E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Thallium	1	1	1E+00
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Thallium	0.37	1	4E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Thallium	0.4	1	4E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Thallium	1	1	1E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Thallium	1	1	1E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Thallium	0.8	1	8E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Thallium	0.9	1	9E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Thallium	2	1	2E+00

## APPENDIX H

### Detailed Risk Calculations for Terrestrial Plants from Direct Contact with Surface Soil

Citation	Location ID	Sample ID	Reach ID	Site or Ref	Analysis Type	Parameter	Conc (mg/kg)	Selected Phytotoxicity Benchmark (mg/kg dw)	Vegetation HQ
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Thallium	0.3425	1	3E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Thallium	0.3	1	3E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Thallium	0.25	1	3E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Thallium	0.3	1	3E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Thallium	0.25	1	3E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Thallium	0.25	1	3E-01
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Vanadium	38	2	2E+01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Vanadium	13.65	2	7E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Vanadium	13	2	7E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Vanadium	11	2	6E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Vanadium	13	2	7E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Vanadium	11	2	6E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Vanadium	23.0667	2	1E+01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Vanadium	16	2	8E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Vanadium	26	2	1E+01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Vanadium	37	2	2E+01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Vanadium	33	2	2E+01
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Vanadium	24.85	2	1E+01
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Vanadium	13	2	7E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Vanadium	26	2	1E+01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Vanadium	52	2	3E+01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Vanadium	29	2	1E+01
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Vanadium	26.8	2	1E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Vanadium	30.45	2	2E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Vanadium	16	2	8E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Vanadium	26	2	1E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Vanadium	21	2	1E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Vanadium	27	2	1E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Vanadium	36	2	2E+01
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Vanadium	26.1	2	1E+01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Vanadium	16	2	8E+00
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Vanadium	13.5	2	7E+00
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Vanadium	17	2	9E+00

## APPENDIX H

### Detailed Risk Calculations for Terrestrial Plants from Direct Contact with Surface Soil

Citation	Location ID	Sample ID	Reach ID	Site or Ref	Analysis Type	Parameter	Conc (mg/kg)	Selected Phytotoxicity Benchmark (mg/kg dw)	Vegetation HQ
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Vanadium	16.5	2	8E+00
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Vanadium	20	2	1E+01
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Zinc	85.6	50	2E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Zinc	36.4	50	7E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Zinc	31	50	6E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Zinc	27	50	5E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Zinc	31	50	6E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Zinc	31	50	6E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Zinc	77.1667	50	2E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Zinc	68	50	1E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Zinc	83	50	2E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Zinc	167	50	3E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Zinc	90	50	2E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Zinc	63.95	50	1E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Zinc	58	50	1E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Zinc	100	50	2E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Zinc	78	50	2E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Zinc	86	50	2E+00
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Zinc	70.9	50	1E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Zinc	66.55	50	1E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Zinc	62	50	1E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Zinc	65	50	1E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Zinc	57	50	1E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Zinc	66	50	1E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Zinc	92	50	2E+00
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Zinc	65.2	50	1E+00
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Zinc	36	50	7E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Zinc	42	50	8E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Zinc	45	50	9E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Zinc	34.5	50	7E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Zinc	51	50	1E+00

## **APPENDIX I**

### **DETAILED RISK CALCULATIONS FOR SOIL ORGANISMS FROM DIRECT CONTACT WITH SURFACE SOIL**

# APPENDIX I

## Detailed Risk Calculations for Soil Organisms from Direct Contact with Surface Soil

Citation	Location ID	Sample ID	Reach ID	Site or Ref	Analysis Type	Parameter	Conc (mg/kg)	Selected Soil Invert Benchmark (mg/kg dw)	Soil Invert HQ
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Aluminum	9540	600	2E+01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Aluminum	3485	600	6E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Aluminum	3200	600	5E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Aluminum	2500	600	4E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Aluminum	2900	600	5E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Aluminum	2300	600	4E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Aluminum	3806.6667	600	6E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Aluminum	3700	600	6E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Aluminum	3700	600	6E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Aluminum	11000	600	2E+01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Aluminum	11000	600	2E+01
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Aluminum	6005	600	1E+01
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Aluminum	4500	600	8E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Aluminum	7400	600	1E+01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Aluminum	19000	600	3E+01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Aluminum	9800	600	2E+01
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Aluminum	6710	600	1E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Aluminum	8905	600	1E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Aluminum	3900	600	7E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Aluminum	8600	600	1E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Aluminum	6000	600	1E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Aluminum	10000	600	2E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Aluminum	14000	600	2E+01
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Aluminum	5955	600	1E+01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Aluminum	6400	600	1E+01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Aluminum	7200	600	1E+01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Aluminum	10000	600	2E+01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Aluminum	10350	600	2E+01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Aluminum	11000	600	2E+01
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Antimony	0.405	NA	NC
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Antimony	3.6425	NA	NC
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Antimony	3.3	NA	NC
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Antimony	6.6	NA	NC
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Antimony	3.45	NA	NC

**APPENDIX I**  
**Detailed Risk Calculations for Soil Organisms from Direct Contact with Surface Soil**

Citation	Location ID	Sample ID	Reach ID	Site or Ref	Analysis Type	Parameter	Conc (mg/kg)	Selected Soil Invert Benchmark (mg/kg dw)	Soil Invert HQ
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Antimony	6.9	NA	NC
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Antimony	2.8333333	NA	NC
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Antimony	9	NA	NC
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Antimony	3.25	NA	NC
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Antimony	4.3	NA	NC
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Antimony	8	NA	NC
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Antimony	6.45	NA	NC
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Antimony	3.4	NA	NC
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Antimony	3.4	NA	NC
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Antimony	16	NA	NC
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Antimony	7	NA	NC
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Antimony	0.37	NA	NC
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Antimony	0.4	NA	NC
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Antimony	3.3	NA	NC
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Antimony	9	NA	NC
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Antimony	7.3	NA	NC
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Antimony	10	NA	NC
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Antimony	7	NA	NC
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Antimony	1.005	NA	NC
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Antimony	3	NA	NC
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Antimony	3.85	NA	NC
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Antimony	3	NA	NC
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Antimony	4	NA	NC
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Antimony	4	NA	NC
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Arsenic	13.4	44.9433086	3E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Arsenic	15.05	44.9433086	3E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Arsenic	0.2	44.9433086	4E-03
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Arsenic	0.4	44.9433086	9E-03
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Arsenic	22	44.9433086	5E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Arsenic	0.5	44.9433086	1E-02
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Arsenic	1466.6667	44.9433086	3E+01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Arsenic	3600	44.9433086	8E+01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Arsenic	1000	44.9433086	2E+01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Arsenic	1500	44.9433086	3E+01

**APPENDIX I**  
**Detailed Risk Calculations for Soil Organisms from Direct Contact with Surface Soil**

Citation	Location ID	Sample ID	Reach ID	Site or Ref	Analysis Type	Parameter	Conc (mg/kg)	Selected Soil Invert Benchmark (mg/kg dw)	Soil Invert HQ
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Arsenic	3500	44.9433086	8E+01
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Arsenic	2550	44.9433086	6E+01
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Arsenic	2700	44.9433086	6E+01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Arsenic	1900	44.9433086	4E+01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Arsenic	8600	44.9433086	2E+02
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Arsenic	3240	44.9433086	7E+01
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Arsenic	1400	44.9433086	3E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Arsenic	2625	44.9433086	6E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Arsenic	3400	44.9433086	8E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Arsenic	2800	44.9433086	6E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Arsenic	960	44.9433086	2E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Arsenic	2500	44.9433086	6E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Arsenic	920	44.9433086	2E+01
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Arsenic	1230	44.9433086	3E+01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Arsenic	0.3	44.9433086	7E-03
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Arsenic	0.15	44.9433086	3E-03
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Arsenic	0.3	44.9433086	7E-03
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Arsenic	0.25	44.9433086	6E-03
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Arsenic	0.25	44.9433086	6E-03
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Barium	171	3000	6E-02
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Barium	108.5	3000	4E-02
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Barium	120	3000	4E-02
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Barium	110	3000	4E-02
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Barium	120	3000	4E-02
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Barium	110	3000	4E-02
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Barium	119.86667	3000	4E-02
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Barium	130	3000	4E-02
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Barium	130	3000	4E-02
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Barium	300	3000	1E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Barium	170	3000	6E-02
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Barium	121.5	3000	4E-02
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Barium	93	3000	3E-02
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Barium	200	3000	7E-02
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Barium	210	3000	7E-02

**APPENDIX I**  
**Detailed Risk Calculations for Soil Organisms from Direct Contact with Surface Soil**

<b>Citation</b>	<b>Location ID</b>	<b>Sample ID</b>	<b>Reach ID</b>	<b>Site or Ref</b>	<b>Analysis Type</b>	<b>Parameter</b>	<b>Conc (mg/kg)</b>	<b>Selected Soil Invert Benchmark (mg/kg dw)</b>	<b>Soil Invert HQ</b>
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Barium	180	3000	6E-02
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Barium	137	3000	5E-02
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Barium	147.5	3000	5E-02
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Barium	90	3000	3E-02
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Barium	150	3000	5E-02
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Barium	120	3000	4E-02
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Barium	160	3000	5E-02
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Barium	190	3000	6E-02
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Barium	143	3000	5E-02
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Barium	140	3000	5E-02
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Barium	135	3000	5E-02
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Barium	310	3000	1E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Barium	300	3000	1E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Barium	240	3000	8E-02
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Boron	15.4	20	8E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Boron	8.1	20	4E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Boron	9	20	5E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Boron	8	20	4E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Boron	8	20	4E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Boron	8	20	4E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Boron	5.5333333	20	3E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Boron	14	20	7E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Boron	8	20	4E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Boron	12	20	6E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Boron	11	20	6E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Boron	7.5	20	4E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Boron	9	20	5E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Boron	8	20	4E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Boron	11	20	6E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Boron	9	20	5E-01
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Boron	6.8	20	3E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Boron	7.4	20	4E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Boron	9	20	5E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Boron	6	20	3E-01

**APPENDIX I**  
**Detailed Risk Calculations for Soil Organisms from Direct Contact with Surface Soil**

Citation	Location ID	Sample ID	Reach ID	Site or Ref	Analysis Type	Parameter	Conc (mg/kg)	Selected Soil Invert Benchmark (mg/kg dw)	Soil Invert HQ
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Boron	8	20	4E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Boron	8	20	4E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Boron	7	20	4E-01
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Boron	5.25	20	3E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Boron	10	20	5E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Boron	4.5	20	2E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Boron	1.5	20	8E-02
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Boron	2.25	20	1E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Boron	5	20	3E-01
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Chromium	12.3	5.180040128	2E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Chromium	6.45	5.180040128	1E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Chromium	6	5.180040128	1E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Chromium	4	5.180040128	8E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Chromium	5	5.180040128	1E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Chromium	4	5.180040128	8E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Chromium	10	5.180040128	2E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Chromium	8	5.180040128	2E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Chromium	10	5.180040128	2E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Chromium	22	5.180040128	4E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Chromium	20	5.180040128	4E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Chromium	11.05	5.180040128	2E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Chromium	7	5.180040128	1E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Chromium	14	5.180040128	3E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Chromium	23	5.180040128	4E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Chromium	17	5.180040128	3E+00
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Chromium	12.1	5.180040128	2E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Chromium	13.9	5.180040128	3E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Chromium	7	5.180040128	1E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Chromium	13	5.180040128	3E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Chromium	10	5.180040128	2E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Chromium	15	5.180040128	3E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Chromium	18	5.180040128	3E+00
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Chromium	11.65	5.180040128	2E+00
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Chromium	8	5.180040128	2E+00

**APPENDIX I**  
**Detailed Risk Calculations for Soil Organisms from Direct Contact with Surface Soil**

Citation	Location ID	Sample ID	Reach ID	Site or Ref	Analysis Type	Parameter	Conc (mg/kg)	Selected Soil Invert Benchmark (mg/kg dw)	Soil Invert HQ
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Chromium	9	5.180040128	2E+00
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Chromium	11	5.180040128	2E+00
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Chromium	14.5	5.180040128	3E+00
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Chromium	12	5.180040128	2E+00
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Copper	25.9	74.00828045	3E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Copper	7.9	74.00828045	1E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Copper	6	74.00828045	8E-02
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Copper	4	74.00828045	5E-02
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Copper	6	74.00828045	8E-02
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Copper	5	74.00828045	7E-02
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Copper	42.933333	74.00828045	6E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Copper	37	74.00828045	5E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Copper	29	74.00828045	4E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Copper	98	74.00828045	1E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Copper	70	74.00828045	9E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Copper	63.5	74.00828045	9E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Copper	39	74.00828045	5E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Copper	68	74.00828045	9E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Copper	140	74.00828045	2E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Copper	75	74.00828045	1E+00
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Copper	45.1	74.00828045	6E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Copper	54.4	74.00828045	7E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Copper	34	74.00828045	5E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Copper	50	74.00828045	7E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Copper	30	74.00828045	4E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Copper	65	74.00828045	9E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Copper	56	74.00828045	8E-01
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Copper	42	74.00828045	6E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Copper	11	74.00828045	1E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Copper	9	74.00828045	1E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Copper	14	74.00828045	2E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Copper	13.5	74.00828045	2E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Copper	14	74.00828045	2E-01
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Iron	20000	200	1E+02

**APPENDIX I**  
**Detailed Risk Calculations for Soil Organisms from Direct Contact with Surface Soil**

Citation	Location ID	Sample ID	Reach ID	Site or Ref	Analysis Type	Parameter	Conc (mg/kg)	Selected Soil Invert Benchmark (mg/kg dw)	Soil Invert HQ
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Iron	6675	200	3E+01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Iron	6200	200	3E+01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Iron	5200	200	3E+01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Iron	6200	200	3E+01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Iron	5000	200	3E+01
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Iron	44233.333	200	2E+02
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Iron	43000	200	2E+02
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Iron	49000	200	2E+02
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Iron	53000	200	3E+02
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Iron	82000	200	4E+02
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Iron	69500	200	3E+02
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Iron	4900	200	2E+01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Iron	48000	200	2E+02
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Iron	120000	200	6E+02
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Iron	74000	200	4E+02
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Iron	54100	200	3E+02
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Iron	85850	200	4E+02
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Iron	54000	200	3E+02
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Iron	79000	200	4E+02
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Iron	45000	200	2E+02
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Iron	8200	200	4E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Iron	83000	200	4E+02
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Iron	53450	200	3E+02
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Iron	12000	200	6E+01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Iron	8150	200	4E+01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Iron	11000	200	6E+01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Iron	9550	200	5E+01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Iron	12000	200	6E+01
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Lead	15.7	392.0513506	4E-02
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Lead	23.45	392.0513506	6E-02
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Lead	22	392.0513506	6E-02
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Lead	23	392.0513506	6E-02
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Lead	28	392.0513506	7E-02
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Lead	20	392.0513506	5E-02

**APPENDIX I**  
**Detailed Risk Calculations for Soil Organisms from Direct Contact with Surface Soil**

Citation	Location ID	Sample ID	Reach ID	Site or Ref	Analysis Type	Parameter	Conc (mg/kg)	Selected Soil Invert Benchmark (mg/kg dw)	Soil Invert HQ
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Lead	22.966667	392.0513506	6E-02
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Lead	24	392.0513506	6E-02
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Lead	20	392.0513506	5E-02
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Lead	58	392.0513506	1E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Lead	30	392.0513506	8E-02
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Lead	19.95	392.0513506	5E-02
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Lead	10	392.0513506	3E-02
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Lead	32	392.0513506	8E-02
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Lead	38	392.0513506	1E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Lead	30	392.0513506	8E-02
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Lead	18.3	392.0513506	5E-02
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Lead	17.6	392.0513506	4E-02
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Lead	10	392.0513506	3E-02
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Lead	10	392.0513506	3E-02
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Lead	10	392.0513506	3E-02
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Lead	10	392.0513506	3E-02
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Lead	20	392.0513506	5E-02
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Lead	23.55	392.0513506	6E-02
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Lead	20	392.0513506	5E-02
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Lead	10	392.0513506	3E-02
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Lead	20	392.0513506	5E-02
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Lead	20	392.0513506	5E-02
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Lead	20	392.0513506	5E-02
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Manganese	639	100	6E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Manganese	295.5	100	3E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Manganese	290	100	3E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Manganese	250	100	3E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Manganese	280	100	3E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Manganese	240	100	2E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Manganese	922.33333	100	9E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Manganese	970	100	1E+01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Manganese	700	100	7E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Manganese	1800	100	2E+01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Manganese	1800	100	2E+01

**APPENDIX I**  
**Detailed Risk Calculations for Soil Organisms from Direct Contact with Surface Soil**

Citation	Location ID	Sample ID	Reach ID	Site or Ref	Analysis Type	Parameter	Conc (mg/kg)	Selected Soil Invert Benchmark (mg/kg dw)	Soil Invert HQ
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Manganese	592	100	6E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Manganese	1100	100	1E+01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Manganese	1400	100	1E+01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Manganese	990	100	1E+01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Manganese	1800	100	2E+01
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Manganese	998	100	1E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Manganese	1290	100	1E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Manganese	730	100	7E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Manganese	1200	100	1E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Manganese	920	100	9E+00
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Manganese	980	100	1E+01
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Manganese	2800	100	3E+01
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Manganese	961	100	1E+01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Manganese	440	100	4E+00
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Manganese	145	100	1E+00
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Manganese	430	100	4E+00
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Manganese	280	100	3E+00
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Manganese	490	100	5E+00
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Mercury	0.03	1.126085875	3E-02
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Mercury	1.09	1.126085875	1E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Mercury	0.005	1.126085875	4E-03
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Mercury	0.005	1.126085875	4E-03
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Mercury	0.005	1.126085875	4E-03
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Mercury	0.01	1.126085875	9E-03
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Mercury	0.2866667	1.126085875	3E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Mercury	0.5	1.126085875	4E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Mercury	0.3	1.126085875	3E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Mercury	1	1.126085875	9E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Mercury	1	1.126085875	9E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Mercury	0.21	1.126085875	2E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Mercury	2	1.126085875	2E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Mercury	2	1.126085875	2E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Mercury	2	1.126085875	2E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Mercury	0.9	1.126085875	8E-01

**APPENDIX I**  
**Detailed Risk Calculations for Soil Organisms from Direct Contact with Surface Soil**

<b>Citation</b>	<b>Location ID</b>	<b>Sample ID</b>	<b>Reach ID</b>	<b>Site or Ref</b>	<b>Analysis Type</b>	<b>Parameter</b>	<b>Conc (mg/kg)</b>	<b>Selected Soil Invert Benchmark (mg/kg dw)</b>	<b>Soil Invert HQ</b>
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Mercury	0.34	1.126085875	3E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Mercury	0.915	1.126085875	8E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Mercury	1	1.126085875	9E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Mercury	1	1.126085875	9E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Mercury	0.01	1.126085875	9E-03
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Mercury	1	1.126085875	9E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Mercury	1	1.126085875	9E-01
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Mercury	0.345	1.126085875	3E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Mercury	1	1.126085875	9E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Mercury	0.005	1.126085875	4E-03
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Mercury	0.01	1.126085875	9E-03
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Mercury	0.005	1.126085875	4E-03
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Mercury	0.005	1.126085875	4E-03
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Molybdenum	3.4	200	2E-02
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Molybdenum	0.58	200	3E-03
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Molybdenum	0.4	200	2E-03
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Molybdenum	0.4	200	2E-03
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Molybdenum	0.8	200	4E-03
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Molybdenum	0.7	200	4E-03
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Molybdenum	2.0666667	200	1E-02
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Molybdenum	1	200	5E-03
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Molybdenum	2	200	1E-02
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Molybdenum	1	200	5E-03
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Molybdenum	1	200	5E-03
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Molybdenum	3.65	200	2E-02
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Molybdenum	0.4	200	2E-03
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Molybdenum	0.4	200	2E-03
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Molybdenum	0.45	200	2E-03
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Molybdenum	0.4	200	2E-03
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Molybdenum	1.8	200	9E-03
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Molybdenum	1.4	200	7E-03
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Molybdenum	0.4	200	2E-03
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Molybdenum	0.45	200	2E-03
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Molybdenum	1	200	5E-03

**APPENDIX I**  
**Detailed Risk Calculations for Soil Organisms from Direct Contact with Surface Soil**

<b>Citation</b>	<b>Location ID</b>	<b>Sample ID</b>	<b>Reach ID</b>	<b>Site or Ref</b>	<b>Analysis Type</b>	<b>Parameter</b>	<b>Conc (mg/kg)</b>	<b>Selected Soil Invert Benchmark (mg/kg dw)</b>	<b>Soil Invert HQ</b>
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Molybdenum	0.4	200	2E-03
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Molybdenum	0.4	200	2E-03
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Molybdenum	1.9	200	1E-02
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Molybdenum	0.55	200	3E-03
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Molybdenum	0.45	200	2E-03
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Molybdenum	0.5	200	3E-03
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Molybdenum	0.45	200	2E-03
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Molybdenum	0.45	200	2E-03
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Nickel	27.9	100.6437569	3E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Nickel	7.4	100.6437569	7E-02
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Nickel	8	100.6437569	8E-02
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Nickel	6	100.6437569	6E-02
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Nickel	5	100.6437569	5E-02
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Nickel	6	100.6437569	6E-02
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Nickel	21.3	100.6437569	2E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Nickel	18	100.6437569	2E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Nickel	19	100.6437569	2E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Nickel	42	100.6437569	4E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Nickel	22	100.6437569	2E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Nickel	14.1	100.6437569	1E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Nickel	8	100.6437569	8E-02
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Nickel	28	100.6437569	3E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Nickel	26	100.6437569	3E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Nickel	22	100.6437569	2E-01
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Nickel	21.7	100.6437569	2E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Nickel	19.15	100.6437569	2E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Nickel	8	100.6437569	8E-02
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Nickel	7	100.6437569	7E-02
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Nickel	16	100.6437569	2E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Nickel	10	100.6437569	1E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Nickel	16	100.6437569	2E-01
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Nickel	19.8	100.6437569	2E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Nickel	7	100.6437569	7E-02
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Nickel	9.5	100.6437569	9E-02

# APPENDIX I

## Detailed Risk Calculations for Soil Organisms from Direct Contact with Surface Soil

Citation	Location ID	Sample ID	Reach ID	Site or Ref	Analysis Type	Parameter	Conc (mg/kg)	Selected Soil Invert Benchmark (mg/kg dw)	Soil Invert HQ
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Nickel	13	100.6437569	1E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Nickel	9.5	100.6437569	9E-02
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Nickel	13	100.6437569	1E-01
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Silver	0.07	50	1E-03
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Silver	0.3325	50	7E-03
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Silver	0.3	50	6E-03
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Silver	0.6	50	1E-02
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Silver	0.3	50	6E-03
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Silver	0.6	50	1E-02
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Silver	0.7833333	50	2E-02
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Silver	1	50	2E-02
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Silver	1	50	2E-02
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Silver	2	50	4E-02
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Silver	2	50	4E-02
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Silver	0.66	50	1E-02
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Silver	1	50	2E-02
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Silver	2	50	4E-02
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Silver	3	50	6E-02
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Silver	2	50	4E-02
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Silver	0.16	50	3E-03
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Silver	0.43	50	9E-03
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Silver	2	50	4E-02
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Silver	1	50	2E-02
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Silver	0.7	50	1E-02
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Silver	1	50	2E-02
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Silver	2	50	4E-02
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Silver	0.18	50	4E-03
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Silver	0.4	50	8E-03
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Silver	0.3	50	6E-03
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Silver	0.35	50	7E-03
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Silver	0.325	50	7E-03
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Silver	0.35	50	7E-03
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Thallium	0.405	NA	NC
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Thallium	0.4425	NA	NC

**APPENDIX I**  
**Detailed Risk Calculations for Soil Organisms from Direct Contact with Surface Soil**

Citation	Location ID	Sample ID	Reach ID	Site or Ref	Analysis Type	Parameter	Conc (mg/kg)	Selected Soil Invert Benchmark (mg/kg dw)	Soil Invert HQ
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Thallium	0.2	NA	NC
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Thallium	0.2	NA	NC
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Thallium	0.25	NA	NC
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Thallium	0.5	NA	NC
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Thallium	0.7166667	NA	NC
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Thallium	0.7	NA	NC
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Thallium	0.7	NA	NC
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Thallium	2	NA	NC
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Thallium	0.9	NA	NC
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Thallium	0.57	NA	NC
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Thallium	0.6	NA	NC
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Thallium	2	NA	NC
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Thallium	1	NA	NC
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Thallium	1	NA	NC
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Thallium	0.37	NA	NC
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Thallium	0.4	NA	NC
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Thallium	1	NA	NC
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Thallium	1	NA	NC
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Thallium	0.8	NA	NC
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Thallium	0.9	NA	NC
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Thallium	2	NA	NC
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Thallium	0.3425	NA	NC
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Thallium	0.3	NA	NC
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Thallium	0.25	NA	NC
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Thallium	0.3	NA	NC
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Thallium	0.25	NA	NC
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Thallium	0.25	NA	NC
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Vanadium	38	33.1662479	1E+00
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Vanadium	13.65	33.1662479	4E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Vanadium	13	33.1662479	4E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Vanadium	11	33.1662479	3E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Vanadium	13	33.1662479	4E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Vanadium	11	33.1662479	3E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Vanadium	23.066667	33.1662479	7E-01

**APPENDIX I**  
**Detailed Risk Calculations for Soil Organisms from Direct Contact with Surface Soil**

Citation	Location ID	Sample ID	Reach ID	Site or Ref	Analysis Type	Parameter	Conc (mg/kg)	Selected Soil Invert Benchmark (mg/kg dw)	Soil Invert HQ
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Vanadium	16	33.1662479	5E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Vanadium	26	33.1662479	8E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Vanadium	37	33.1662479	1E+00
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Vanadium	33	33.1662479	1E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Vanadium	24.85	33.1662479	7E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Vanadium	13	33.1662479	4E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Vanadium	26	33.1662479	8E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Vanadium	52	33.1662479	2E+00
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Vanadium	29	33.1662479	9E-01
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Vanadium	26.8	33.1662479	8E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Vanadium	30.45	33.1662479	9E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Vanadium	16	33.1662479	5E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Vanadium	26	33.1662479	8E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Vanadium	21	33.1662479	6E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Vanadium	27	33.1662479	8E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Vanadium	36	33.1662479	1E+00
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Vanadium	26.1	33.1662479	8E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Vanadium	16	33.1662479	5E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Vanadium	13.5	33.1662479	4E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Vanadium	17	33.1662479	5E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Vanadium	16.5	33.1662479	5E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Vanadium	20	33.1662479	6E-01
EPA (1999) - Terrestrial	BFR-R-10	BFR-R-10	BFRu	Ref	Total	Zinc	85.6	209.3270279	4E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12	OTHER	Ref	Total	Zinc	36.4	209.3270279	2E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-03-01	OTHER	Ref	Total	Zinc	31	209.3270279	1E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-04-01	OTHER	Ref	Total	Zinc	27	209.3270279	1E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-06-01	OTHER	Ref	Total	Zinc	31	209.3270279	1E-01
EPA (1999) - Terrestrial	SPC-R-12	SPC-R-12-10-01	OTHER	Ref	Total	Zinc	31	209.3270279	1E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05	WWC	Site	Total	Zinc	77.166667	209.3270279	4E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-24	WWC	Site	Total	Zinc	68	209.3270279	3E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-01-42	WWC	Site	Total	Zinc	83	209.3270279	4E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-23	WWC	Site	Total	Zinc	167	209.3270279	8E-01
EPA (1999) - Terrestrial	WWC-05	WWC-05-02-32	WWC	Site	Total	Zinc	90	209.3270279	4E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06	WWC	Site	Total	Zinc	63.95	209.3270279	3E-01

**APPENDIX I**  
**Detailed Risk Calculations for Soil Organisms from Direct Contact with Surface Soil**

<b>Citation</b>	<b>Location ID</b>	<b>Sample ID</b>	<b>Reach ID</b>	<b>Site or Ref</b>	<b>Analysis Type</b>	<b>Parameter</b>	<b>Conc (mg/kg)</b>	<b>Selected Soil Invert Benchmark (mg/kg dw)</b>	<b>Soil Invert HQ</b>
EPA (1999) - Terrestrial	WWC-06	WWC-06-01-18	WWC	Site	Total	Zinc	58	209.3270279	3E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-05	WWC	Site	Total	Zinc	100	209.3270279	5E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-07	WWC	Site	Total	Zinc	78	209.3270279	4E-01
EPA (1999) - Terrestrial	WWC-06	WWC-06-02-15	WWC	Site	Total	Zinc	86	209.3270279	4E-01
EPA (1999) - Terrestrial	WWC-07	WWC-07	WWC	Site	Total	Zinc	70.9	209.3270279	3E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08	WWC	Site	Total	Zinc	66.55	209.3270279	3E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-02	WWC	Site	Total	Zinc	62	209.3270279	3E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-06	WWC	Site	Total	Zinc	65	209.3270279	3E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-01-20	WWC	Site	Total	Zinc	57	209.3270279	3E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-03-06	WWC	Site	Total	Zinc	66	209.3270279	3E-01
EPA (1999) - Terrestrial	WWC-08	WWC-08-06-17	WWC	Site	Total	Zinc	92	209.3270279	4E-01
EPA (1999) - Terrestrial	WWC-09	WWC-09	WWC	Site	Total	Zinc	65.2	209.3270279	3E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-01-06	WWC	Ref	Total	Zinc	36	209.3270279	2E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-01	WWC	Ref	Total	Zinc	42	209.3270279	2E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-04-09	WWC	Ref	Total	Zinc	45	209.3270279	2E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-06-10	WWC	Ref	Total	Zinc	34.5	209.3270279	2E-01
EPA (1999) - Terrestrial	WWC-R-01 A	WWC-R-01-07-02	WWC	Ref	Total	Zinc	51	209.3270279	2E-01

## **APPENDIX J**

### **SUMMARY OF COPC BIOACCUMULATION FROM SOIL AND SEDIMENT INTO BIOTA TISSUE**

**APPENDIX J**  
**COMPARISON OF SOIL CONCENTRATIONS TO TISSUE CONCENTRATIONS**

Analyte	Tissue Type	slope	intercept	R	p value
Aluminum	<b>Sweet Clover</b>	2.3E-03	7.3E+00	8.7E-01	2.6E-02
	Composite Grasses	-2.3E-03	7.2E+01	-2.1E-01	1.7E-01
	Terrestrial Invertebrates	-2.4E-03	5.0E+01	-2.0E-01	4.0E-01
	<b>Soil Invertebrates</b>	3.6E-02	-5.2E+01	8.8E-01	2.5E-02
	Small Mammals	3.7E-03	1.1E+02	8.3E-02	3.6E-01
Antimony	<b>Sweet Clover</b>	9.7E-03	1.8E-01	7.8E-01	6.0E-02
	Composite Grasses	-5.5E-03	2.0E-01	-3.9E-01	3.7E-02
	Terrestrial Invertebrates	0.0E+00	1.5E+00	#DIV/0!	#VALUE!
	<b>Soil Invertebrates</b>	1.7E-02	2.9E-01	1.0E+00	3.7E-05
	Small Mammals	4.8E-16	3.0E+00	#DIV/0!	#VALUE!
Arsenic	<b>Sweet Clover</b>	5.1E-03	-1.6E+00	9.4E-01	8.7E-03
	<b>Composite Grasses</b>	1.4E-03	2.5E-01	7.9E-01	5.4E-06
	Terrestrial Invertebrates	9.0E-04	6.7E-01	8.3E-01	8.3E-02
	Soil Invertebrates	1.4E-01	8.2E+01	7.9E-01	5.5E-02
	Small Mammals	1.5E-03	2.2E+00	7.0E-01	3.1E-04
Barium	<b>Sweet Clover</b>	2.1E-02	1.3E+01	2.0E-02	4.9E-01
	Composite Grasses	1.1E-01	5.0E+00	4.1E-01	2.9E-02
	Terrestrial Invertebrates	3.7E-02	-2.0E+00	3.7E-01	3.1E-01
	<b>Soil Invertebrates</b>	2.6E-02	3.3E+00	1.0E+00	3.1E-05
	Small Mammals	2.7E-02	5.1E+00	3.2E-01	8.4E-02
Beryllium	<b>Sweet Clover</b>	4.7E-02	2.3E-01	2.0E-01	3.8E-01
	Composite Grasses	1.4E-02	1.6E-01	2.6E-01	1.2E-01
	Terrestrial Invertebrates	0.0E+00	5.0E-02	#DIV/0!	#VALUE!
	Soil Invertebrates	-7.2E-02	3.7E-01	-4.7E-01	2.1E-01
	Small Mammals	0.0E+00	1.0E-01	0.0E+00	5.0E-01
Cadmium	<b>Sweet Clover</b>	6.7E-02	5.2E-01	8.0E-01	5.3E-02
	Composite Grasses	-1.1E-01	5.5E-01	-3.7E-01	4.6E-02
	Terrestrial Invertebrates	-5.0E-02	4.7E-01	-2.1E-01	4.0E-01
	Soil Invertebrates	3.2E+00	-5.1E-01	7.7E-01	6.2E-02
	Small Mammals	-2.2E-02	3.3E-01	-2.7E-01	1.3E-01
Chromium	<b>Sweet Clover</b>	8.1E-03	5.4E-01	2.5E-01	3.4E-01
	Composite Grasses	-6.5E-03	5.6E-01	-1.9E-01	2.0E-01
	Terrestrial Invertebrates	1.5E+00	-6.8E+00	7.5E-01	1.3E-01
	Soil Invertebrates	1.5E-01	7.3E-01	6.1E-01	1.4E-01
	Small Mammals	1.7E-02	3.0E+00	5.1E-02	4.2E-01
Copper	<b>Sweet Clover</b>	2.8E-02	7.5E+00	7.9E-01	5.8E-02
	Composite Grasses	-1.4E-03	4.1E+00	-3.9E-02	4.3E-01
	Terrestrial Invertebrates	1.3E-01	2.8E+01	8.2E-01	8.8E-02
	Soil Invertebrates	1.2E-02	1.1E+01	1.9E-01	3.8E-01
	Small Mammals	1.6E-02	9.8E+00	2.4E-01	1.5E-01
Lead	<b>Sweet Clover</b>	8.4E-04	2.5E-01	3.3E-01	3.0E-01
	Composite Grasses	4.3E-03	1.9E-01	2.0E-01	1.9E-01
	Terrestrial Invertebrates	-9.1E-03	2.4E-01	-8.9E-01	5.5E-02
	Soil Invertebrates	4.2E-03	5.0E-01	2.5E-01	3.5E-01
	Small Mammals	-1.1E-02	8.9E-01	-1.4E-01	2.8E-01
Manganese	<b>Sweet Clover</b>	1.5E-03	2.4E+01	1.2E-01	4.2E-01
	Composite Grasses	-9.4E-03	1.6E+02	-4.0E-02	4.3E-01
	Terrestrial Invertebrates	-3.0E-02	3.8E+01	-4.9E-01	2.5E-01
	Soil Invertebrates	5.5E-02	-1.4E+01	5.8E-01	1.5E-01
	Small Mammals	-7.0E-04	1.4E+01	-5.4E-02	4.1E-01
Mercury	<b>Sweet Clover</b>	-2.5E-03	6.4E-02	-3.4E-01	2.9E-01
	Composite Grasses	-8.0E-03	5.5E-02	-4.0E-01	3.4E-02
	Terrestrial Invertebrates	-6.5E-04	1.4E-02	-6.3E-01	1.9E-01
	<b>Soil Invertebrates</b>	1.5E-01	2.1E-01	9.9E-01	4.9E-04
	Small Mammals	-1.7E-02	7.8E-02	-1.6E-01	2.6E-01
Thallium	<b>Sweet Clover</b>	-2.1E-02	2.6E-01	-1.8E-01	3.9E-01
	Composite Grasses	-4.0E-02	2.0E-01	-5.1E-01	7.6E-03
	Terrestrial Invertebrates	0.0E+00	1.0E-02	#DIV/0!	#VALUE!
	<b>Soil Invertebrates</b>	5.3E-01	1.2E-01	1.0E+00	2.1E-07
	Small Mammals	3.5E-03	1.8E-02	4.8E-01	1.6E-02
Vanadium	<b>Sweet Clover</b>	-9.0E-03	1.4E+00	-3.9E-01	2.6E-01
	Composite Grasses	-8.6E-03	1.0E+00	-3.9E-01	3.6E-02
	Terrestrial Invertebrates	-1.2E-02	4.4E-01	-4.2E-01	2.9E-01
	<b>Soil Invertebrates</b>	1.8E-02	8.3E-01	9.3E-01	1.2E-02
	Small Mammals	-2.0E-03	4.9E-01	-9.7E-02	3.4E-01
Zinc	<b>Sweet Clover</b>	-6.0E-03	3.0E+01	-2.5E-02	4.8E-01
	Composite Grasses	-2.4E-02	2.4E+01	-1.4E-01	2.7E-01
	Terrestrial Invertebrates	-6.0E-02	1.4E+02	-6.9E-02	4.7E-01
	Soil Invertebrates	5.4E-04	1.0E+02	1.5E-02	4.9E-01
	Small Mammals	4.7E-02	1.0E+02	8.5E-02	3.6E-01

**APPENDIX J**  
**COMPARISON OF SEDIMENT CONCENTRATIONS TO TISSUE CONCENTRATIONS**

Analyte	Tissue Type	slope	intercept	R	p value
Aluminum	Benthic (non-dep)	1.1E-01	2.3E+02	5.3E-01	1.2E-01
	Benthic (dep)	6.8E-02	1.2E+02	5.4E-01	3.5E-01
Antimony	Benthic (non-dep)	5.5E-02	2.0E-02	5.0E-01	1.4E-01
	Benthic (dep)	3.2E-02	-3.5E-03	8.3E-01	8.1E-02
Arsenic	Benthic (non-dep)	-2.3E-02	9.5E+01	-1.0E-01	7.7E-01
	<b>Benthic (dep)</b>	1.3E-01	-1.8E+01	9.3E-01	2.0E-02
Barium	Benthic (non-dep)	-6.0E-02	4.0E+01	-1.9E-01	5.9E-01
	Benthic (dep)	-9.4E-02	5.0E+01	-5.0E-01	3.9E-01
Beryllium	Benthic (non-dep)	3.1E-02	2.3E-02	1.4E-01	7.1E-01
	Benthic (dep)	4.8E-02	4.7E-03	3.0E-01	6.2E-01
Cadmium	Benthic (non-dep)	1.4E-03	1.7E-01	3.3E-03	9.9E-01
	Benthic (dep)	3.8E-02	1.6E-01	8.7E-02	8.9E-01
Chromium	Benthic (non-dep)	2.2E-02	4.2E+00	3.8E-01	2.8E-01
	Benthic (dep)	6.3E-02	3.6E+00	6.7E-01	2.1E-01
Copper	<b>Benthic (non-dep)</b>	1.9E-01	1.3E+01	8.3E-01	2.8E-03
	Benthic (dep)	1.6E-01	1.4E+01	8.4E-01	7.8E-02
Lead	Benthic (non-dep)	-4.1E-04	1.4E+00	-5.1E-02	8.9E-01
	Benthic (dep)	-1.1E-03	1.2E+00	-2.2E-01	7.2E-01
Manganese	Benthic (non-dep)	1.1E+00	5.6E+01	2.6E-01	4.7E-01
	Benthic (dep)	1.3E+00	-1.4E+02	3.1E-01	6.2E-01
Mercury	Benthic (non-dep)	1.3E-01	1.4E-01	2.3E-01	7.7E-01
	<b>Benthic (dep)</b>	8.6E-02	1.1E-01	1.0E+00	4.8E-02
Thallium	Benthic (non-dep)	4.4E-02	6.0E-02	4.2E-02	9.1E-01
	Benthic (dep)	-5.5E-02	1.1E-01	-8.0E-02	9.0E-01
Vanadium	Benthic (non-dep)	3.6E-02	2.7E+00	3.2E-01	3.7E-01
	Benthic (dep)	3.9E-03	2.8E+00	6.3E-02	9.2E-01
Zinc	Benthic (non-dep)	8.4E-02	1.5E+02	6.9E-02	8.5E-01
	Benthic (dep)	-2.0E-01	2.1E+02	-1.7E-01	7.9E-01

## **APPENDIX K**

### **WILDLIFE TOXICITY REFERENCE VALUE (TRV) DERIVATION**

**TRV CALCULATION WORKSHEET FOOTNOTES:**

1 If no study is available to establish a LOAEL TRV, the LOAEL is set to equal 3 x NOAEL

2  $TRV(\text{food}) = TRV(\text{water}) / 0.50$

3 Test species uncertainty factor equals 1 since both Old World and New World mice are physiologically similar;  
and laboratory rodents are often more sensitive than wild species due to genetic heterogeneity of natural populations.

4  $TRV(\text{water or capsule}) = TRV(\text{food}) * 0.50$

5  $TRV = \text{Study Dose} / UF$

SMF = Study Modifying Factor

NA = Not Available

UF = Uncertainty Factor

NOAEL = No observed adverse effect level

LOAEL = Lowest observed adverse effect level

BW = Body Weight

TRV = Toxicity Reference Value

NOAEL & LOAEL TRVs - ALUMINUM

Receptor	Study	Chemical	Route	Study Test Species	Study Factors				NOAEL study conc (ppm)	LOAEL study conc (ppm)	Conversion Factor (kg food/ kg BW/day)	NOAEL dose (mg/kg-day)	LOAEL dose (mg/kg-day) <sup>1</sup>	Uncertainty Factors (UF)					Total UF <sup>6</sup>	NOAEL TRV (mg/kg-day)	LOAEL TRV (mg/kg-day)			
					Duration	N	Doses	Endpoint						Inter-species	Duration	Endpoint		Other						
											NOAEL					LOAEL								
Deer Mouse (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						1.13	5.5
Deer Mouse (diet)	Golub et al., 1987	Aluminum lactate	Oral Diet	Rat	Chronic			Reproduction, Growth	85	413	0.08 ORNL 1996	6.8	33.04	3	1	1	1	1	3	3	2.27	11.01		
Mink (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						1.13	5.5
Mink (diet)	Golub et al., 1987	Aluminum lactate	Oral Diet	Rat	Chronic			Reproduction, Growth	85	413	0.08 ORNL 1996	6.8	33.04	3	1	1	1	1	3	3	2.27	11.01		
Meadow Vole (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						1.13	5.5
Meadow Vole (diet)	Golub et al., 1987	Aluminum lactate	Oral Diet	Rat	Chronic			Reproduction, Growth	85	413	0.08 ORNL 1996	6.8	33.04	3	1	1	1	1	3	3	2.27	11.01		
Masked Shrew (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						1.13	5.5
Masked Shrew (diet)	Golub et al., 1987	Aluminum lactate	Oral Diet	Rat	Chronic			Reproduction, Growth	85	413	0.08 ORNL 1996	6.8	33.04	3	1	1	1	1	3	3	2.27	11.01		
Red Fox (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						1.13	5.5
Red Fox (diet)	Golub et al., 1987	Aluminum lactate	Oral Diet	Rat	Chronic			Reproduction, Growth	85	413	0.08 ORNL 1996	6.8	33.04	3	1	1	1	1	3	3	2.27	11.01		
American Robin (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						3.50	17.5
American Robin (diet)	Sparling, 1990	Aluminum sulphate	Oral Diet	Mallard	Chronic; 10 weeks			Reproduction, Growth	200.0	1,000	0.175 Camardese et al., 1990	35.00	175.0	5	1	1	1	1	5	5	7.00	35.0		
Cliff Swallow (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						3.50	17.5
Cliff Swallow (diet)	Sparling, 1990	Aluminum sulphate	Oral Diet	Mallard	Chronic; 10 weeks			Reproduction, Growth	200.0	1,000	0.175 Camardese et al., 1990	35.00	175.0	5	1	1	1	1	5	5	7.00	35.0		
American Kestrel (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						3.50	17.5
American Kestrel (diet)	Sparling, 1990	Aluminum sulphate	Oral Diet	Mallard	Chronic; 10 weeks			Reproduction, Growth	200.0	1,000	0.175 Camardese et al., 1990	35.00	175.0	5	1	1	1	1	5	5	7.00	35.0		
Belted Kingfisher (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						3.50	17.5
Belted Kingfisher (diet)	Sparling, 1990	Aluminum sulphate	Oral Diet	Mallard	Chronic; 10 weeks			Reproduction, Growth	200.0	1,000	0.175 Camardese et al., 1990	35.00	175.0	5	1	1	1	1	5	5	7.00	35.0		
American Dipper (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						3.50	17.5
American Dipper (diet)	Sparling, 1990	Aluminum sulphate	Oral Diet	Mallard	Chronic; 10 weeks			Reproduction, Growth	200.0	1,000	0.175 Camardese et al., 1990	35.00	175.0	5	1	1	1	1	5	5	7.00	35.0		
Great Horned Owl (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						3.50	17.5
Great Horned Owl (diet)	Sparling, 1990	Aluminum sulphate	Oral Diet	Mallard	Chronic; 10 weeks			Reproduction, Growth	200.0	1,000	0.175 Camardese et al., 1990	35.00	175.0	5	1	1	1	1	5	5	7.00	35.0		

NOAEL & LOAEL TRVs - ANTIMONY

Receptor	Study	Chemical	Route	Study Test Species	Study Factors				NOAEL study conc (ppm)	LOAEL study conc (ppm)	Conversion Factor (kg food/ kg BW/day)	NOAEL dose (mg/kg-day)	LOAEL dose (mg/kg-day) <sup>1</sup>	Uncertainty Factors (UF)					Other	Total UF <sup>2</sup>		NOAEL TRV (mg/kg-day)	LOAEL TRV (mg/kg-day)
					Duration	N	Doses	Endpoint						Inter-species	Duration	Endpoint		NOAEL		LOAEL	NOAEL		
											NOAEL					LOAEL							
Deer Mouse (water)	Schroeder et al., 1968	Antimony potassium tartrate	Oral Water	Mouse	Chronic; 1 yr	>	1 dose of 5 ppm	Lifespan; Longevity	5.00	0.0075 EPA 1988	NA	0.04	1	1	1	1	1	1	1	1.3E-02	3.8E-02		
Deer Mouse (diet)	No Reliable TRV Establishing Studies Found Derive from Water TRV <sup>2</sup>																			2.5E-02	7.5E-02		
Mink (water)	Schroeder et al., 1968	Antimony potassium tartrate	Oral Water	Mouse	Chronic; 1 yr	>	1 dose of 5 ppm	Lifespan; Longevity	5.00	0.0075 EPA 1988	NA	0.04	4	1	1	1	1	4	4	3.1E-03	9.4E-03		
Mink (diet)	No Reliable TRV Establishing Studies Found Derive from Water TRV <sup>2</sup>																			6.3E-03	1.9E-02		
Meadow Vole (water)	Schroeder et al., 1968	Antimony potassium tartrate	Oral Water	Mouse	Chronic; 1 yr	>	1 dose of 5 ppm	Lifespan; Longevity	5.00	0.0075 EPA 1988	NA	0.04	4	1	1	1	1	4	4	3.1E-03	9.4E-03		
Meadow Vole (diet)	No Reliable TRV Establishing Studies Found Derive from Water TRV <sup>2</sup>																			6.3E-03	1.9E-02		
Masked Shrew (water)	Schroeder et al., 1968	Antimony potassium tartrate	Oral Water	Mouse	Chronic; 1 yr	>	1 dose of 5 ppm	Lifespan; Longevity	5.00	0.0075 EPA 1988	NA	0.04	4	1	1	1	1	4	4	3.1E-03	9.4E-03		
Masked Shrew (diet)	No Reliable TRV Establishing Studies Found Derive from Water TRV <sup>2</sup>																			6.3E-03	1.9E-02		
Red Fox (water)	Schroeder et al., 1968	Antimony potassium tartrate	Oral Water	Mouse	Chronic; 1 yr	>	1 dose of 5 ppm	Lifespan; Longevity	5.00	0.0075 EPA 1988	NA	0.04	1	1	1	1	1	1	1	1.3E-02	3.8E-02		
Red Fox (diet)	No Reliable TRV Establishing Studies Found Derive from Water TRV <sup>2</sup>																			2.5E-02	7.5E-02		
American Robin (water)	No Reliable TRV Establishing Studies Found																			NA	NA		
American Robin (diet)	No Reliable TRV Establishing Studies Found																			NA	NA		
Cliff Swallow (water)	No Reliable TRV Establishing Studies Found																			NA	NA		
Cliff Swallow (diet)	No Reliable TRV Establishing Studies Found																			NA	NA		
American Kestrel (water)	No Reliable TRV Establishing Studies Found																			NA	NA		
American Kestrel (diet)	No Reliable TRV Establishing Studies Found																			NA	NA		
Belted Kingfisher (water)	No Reliable TRV Establishing Studies Found																			NA	NA		
Belted Kingfisher (diet)	No Reliable TRV Establishing Studies Found																			NA	NA		
American Dipper (water)	No Reliable TRV Establishing Studies Found																			NA	NA		
American Dipper (diet)	No Reliable TRV Establishing Studies Found																			NA	NA		
Great Horned Owl (water)	No Reliable TRV Establishing Studies Found																			NA	NA		
Great Horned Owl (diet)	No Reliable TRV Establishing Studies Found																			NA	NA		

NOAEL & LOAEL TRVs - ARSENIC

Receptor	Study	Chemical	Route	Study Test Species	Study Factors			NOAEL study conc (ppm)	LOAEL study conc (ppm)	Conversion Factor (kg food/ kg BW/day)	Source	NOAEL dose (mg/kg-day)	LOAEL dose (mg/kg-day) <sup>1</sup>	Uncertainty Factors (UF)						Total UF <sup>5</sup>		NOAEL TRV (mg/kg-day)	LOAEL TRV (mg/kg-day)		
					Duration	N	Doses							Endpoint	Inter-species	Duration	Endpoint		Other						
																	NOAEL	LOAEL		NOAEL	LOAEL				
Deer Mouse (water)	Schroeder & Mitchener, 1971	Arsenite salt	Oral	Charles River CD Mice <sup>3</sup>	Chronic; 3 generations	10 animals in each generation	1 dose of 5.06 ppm (5 ppm water + 0.06 ppm diet)	Reproduction, Growth, Longevity	5.06		0.25	1.27	NA	1	1	1	1	1	1	1	1	1	1	1.3E+00	3.8E+00
Deer Mouse (diet)	No Reliable TRV Establishing Studies Found Derive from Water TRV <sup>4</sup>		Water							ORNL 1996														2.5E+00	7.6E+00
Mink (water)	Schroeder & Mitchener, 1971	Arsenite salt	Oral	Charles River CD Mice <sup>3</sup>	Chronic; 3 generations	10 animals in each generation	1 dose of 5.06 ppm (5 ppm water + 0.06 ppm diet)	Reproduction, Growth, Longevity	5.06		0.25	1.27	NA	5	1	1	1	1	5	5	2.5E-01	7.6E-01			
Mink (diet)	Byron et al., 1967	Sodium arsenite	Oral	Beagle	2 years	6 animals per dose group	4 doses each of arsenite or arsenate	Growth, Mortality	50		0.024	1.2	NA	4	1	1	1	2 Unknown Effect Level	8	8	1.5E-01	4.5E-01			
			Diet				5, 25, 50, 125 ppm			ORNL 1996															
Meadow Vole (water)	Schroeder & Mitchener, 1971	Arsenite salt	Oral	Charles River CD Mice <sup>3</sup>	Chronic; 3 generations	10 animals in each generation	1 dose of 5.06 ppm (5 ppm water + 0.06 ppm diet)	Reproduction, Growth, Longevity	5.06		0.25	1.27	NA	3	1	1	1	1	3	3	4.2E-01	1.3E+00			
Meadow Vole (diet)	Byron et al., 1967	Sodium arsenite	Oral	Beagle	2 years	6 animals per dose group	4 doses each of arsenite or arsenate	Growth, Mortality	50		0.024	1.2	NA	5	1	1	1	2 Unknown Effect Level	10	10	1.2E-01	3.6E-01			
			Diet				5, 25, 50, 125 ppm			ORNL 1996															
Masked Shrew (water)	Schroeder & Mitchener, 1971	Arsenite salt	Oral	Charles River CD Mice <sup>3</sup>	Chronic; 3 generations	10 animals in each generation	1 dose of 5.06 ppm (5 ppm water + 0.06 ppm diet)	Reproduction, Growth, Longevity	5.06		0.25	1.27	NA	5	1	1	1	1	5	5	2.5E-01	7.6E-01			
Masked Shrew (diet)	Byron et al., 1967	Sodium arsenite	Oral	Beagle	2 years	6 animals per dose group	4 doses each of arsenite or arsenate	Growth, Mortality	50		0.024	1.2	NA	5	1	1	1	2 Unknown Effect Level	10	10	1.2E-01	3.6E-01			
			Diet				5, 25, 50, 125 ppm			ORNL 1996															
Red Fox (water)	Schroeder & Mitchener, 1971	Arsenite salt	Oral	Charles River CD Mice <sup>3</sup>	Chronic; 3 generations	10 animals in each generation	1 dose of 5.06 ppm (5 ppm water + 0.06 ppm diet)	Reproduction, Growth, Longevity	5.06		0.25	1.27	NA	5	1	1	1	1	5	5	2.5E-01	7.6E-01			
Red Fox (diet)	Byron et al., 1967	Sodium arsenite	Oral	Beagle	2 years	6 animals per dose group	4 doses each of arsenite or arsenate	Growth, Mortality	50		0.024	1.2	NA	3	1	1	1	2 Unknown Effect Level	6	6	2.0E-01	6.0E-01			
			Diet				5, 25, 50, 125 ppm			ORNL 1996															
American Robin (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						4.1E-01	3.5E+00	
American Robin (diet)	Stanley et al., 1994	Sodium arsenate	Oral	Mallard	Chronic; 8 weeks	12 pairs (24 ducks) per diet	4 doses of 0, 25, 100, 400 ppm (Mean at 100 & 400 – 93 & 403 ppm)	Reproduction, Growth	93	403	0.175 Camardese et al., 1990	16	71	5	1	2	1	2 SMF	20	10	8.1E-01	7.1E+00			
Chiff Swallow (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						4.1E-01	3.5E+00	
Chiff Swallow (diet)	Stanley et al., 1994	Sodium arsenate	Oral	Mallard	Chronic; 8 weeks	12 pairs (24 ducks) per diet	4 doses of 0, 25, 100, 400 ppm (Mean at 100 & 400 – 93 & 403 ppm)	Reproduction, Growth	93	403	0.175 Camardese et al., 1990	16	71	5	1	2	1	2 SMF	20	10	8.1E-01	7.1E+00			
American Kestrel (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						4.1E-01	3.5E+00	
American Kestrel (diet)	Stanley et al., 1994	Sodium arsenate	Oral	Mallard	Chronic; 8 weeks	12 pairs (24 ducks) per diet	4 doses of 0, 25, 100, 400 ppm (Mean at 100 & 400 – 93 & 403 ppm)	Reproduction, Growth	93	403	0.175 Camardese et al., 1990	16	71	5	1	2	1	2 SMF	20	10	8.1E-01	7.1E+00			
Belted Kingfisher (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						4.1E-01	3.5E+00	
Belted Kingfisher (diet)	Stanley et al., 1994	Sodium arsenate	Oral	Mallard	Chronic; 8 weeks	12 pairs (24 ducks) per diet	4 doses of 0, 25, 100, 400 ppm (Mean at 100 & 400 – 93 & 403 ppm)	Reproduction, Growth	93	403	0.175 Camardese et al., 1990	16	71	5	1	2	1	2 SMF	20	10	8.1E-01	7.1E+00			
American Dipper (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						4.1E-01	3.5E+00	
American Dipper (diet)	Stanley et al., 1994	Sodium arsenate	Oral	Mallard	Chronic; 8 weeks	12 pairs (24 ducks) per diet	4 doses of 0, 25, 100, 400 ppm (Mean at 100 & 400 – 93 & 403 ppm)	Reproduction, Growth	93	403	0.175 Camardese et al., 1990	16	71	5	1	2	1	2 SMF	20	10	8.1E-01	7.1E+00			
Great Horned Owl (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						4.1E-01	3.5E+00	
Great Horned Owl (diet)	Stanley et al., 1994	Sodium arsenate	Oral	Mallard	Chronic; 8 weeks	12 pairs (24 ducks) per diet	4 doses of 0, 25, 100, 400 ppm (Mean at 100 & 400 – 93 & 403 ppm)	Reproduction, Growth	93	403	0.175 Camardese et al., 1990	16	71	5	1	2	1	2 SMF	20	10	8.1E-01	7.1E+00			

NOAEL & LOAEL TRVs - BARIUM

Receptor	Study	Chemical	Route	Study Test Species	Study Factors				NOAEL study conc (ppm)	LOAEL study conc (ppm)	Conversion Factor (kg food/ kg BW/day)	NOAEL dose (mg/kg-day)	LOAEL dose (mg/kg-day) <sup>1</sup>	Uncertainty Factors (UF)					Other	Total UF <sup>5</sup>		NOAEL TRV (mg/kg-day)	LOAEL TRV (mg/kg-day)
					Duration	N	Doses	Endpoint			Source			Inter-species	Duration	Endpoint		NOAEL		LOAEL			
																NOAEL	LOAEL						
Deer Mouse (water)	Perry et al 1983	Barium chloride	Oral Water	Rat	16 months		3 exposures 1, 10, 100 ppm	Growth; Hypertension	100.00		0.05 Measured in study	5.06	NA	3	1	1	1	1	3	3	1.7E+00	5.1E+00	
Deer Mouse (diet)	No Reliable TRV Establishing Study Derive from water TRV																				3.4E+00	1.0E+01	
Mink (water)	Perry et al 1983	Barium chloride	Oral Water	Rat	16 months		3 exposures 1, 10, 100 ppm	Growth; Hypertension	100.00		0.05 Measured in study	5.06	NA	5	1	1	1	1	5	5	1.0E+00	3.0E+00	
Mink (diet)	No Reliable TRV Establishing Study Derive from water TRV																				2.0E+00	6.1E+00	
Masked Shrew (water)	Perry et al 1983	Barium chloride	Oral Water	Rat	16 months		3 exposures 1, 10, 100 ppm	Growth; Hypertension	100.00		0.05 Measured in study	5.06	NA	5	1	1	1	1	5	5	1.0E+00	3.0E+00	
Masked Shrew (diet)	No Reliable TRV Establishing Study Derive from water TRV																				2.0E+00	6.1E+00	
Red Fox (water)	Perry et al 1983	Barium chloride	Oral Water	Rat	16 months		3 exposures 1, 10, 100 ppm	Growth; Hypertension	100.00		0.05 Measured in study	5.06	NA	5	1	1	1	1	5	5	1.0E+00	3.0E+00	
Red Fox (diet)	No Reliable TRV Establishing Study Derive from water TRV																				2.0E+00	6.1E+00	
American Robin (water)	No Reliable TRV Establishing Study Derive from dietary TRV																				1.4E+00	2.8E+00	
American Robin (diet)	Johnson et al 1960		Oral Diet	Chicken	4 weeks Subchronic duration		8 exposures 250, 500, 1000, 2000, 4000, 8000, 16,000, 32,000 ppm	Mortality	2,000	4,000	0.104 BW & FCNS - EPA 1988a	208	417	5	5	3	3	1	75	75	2.8E+00	5.6E+00	
American Kestrel (water)	No Reliable TRV Establishing Study Derive from dietary TRV																				1.4E+00	2.8E+00	
American Kestrel (diet)	Johnson et al 1960		Oral Diet	Chicken	4 weeks Subchronic duration		8 exposures 250, 500, 1000, 2000, 4000, 8000, 16,000, 32,000 ppm	Mortality	2,000	4,000	0.104 BW & FCNS - EPA 1988a	208	417	5	5	3	3	1	75	75	2.8E+00	5.6E+00	
Belted Kingfisher (water)	No Reliable TRV Establishing Study Derive from dietary TRV																				1.4E+00	2.8E+00	
Belted Kingfisher (diet)	Johnson et al 1960		Oral Diet	Chicken	4 weeks Subchronic duration		8 exposures 250, 500, 1000, 2000, 4000, 8000, 16,000, 32,000 ppm	Mortality	2,000	4,000	0.104 BW & FCNS - EPA 1988a	208	417	5	5	3	3	1	75	75	2.8E+00	5.6E+00	
American Dipper (water)	No Reliable TRV Establishing Study Derive from dietary TRV																				1.4E+00	2.8E+00	
American Dipper (diet)	Johnson et al 1960		Oral Diet	Chicken	4 weeks Subchronic duration		8 exposures 250, 500, 1000, 2000, 4000, 8000, 16,000, 32,000 ppm	Mortality	2,000	4,000	0.104 BW & FCNS - EPA 1988a	208	417	5	5	3	3	1	75	75	2.8E+00	5.6E+00	
Great Horned Owl (water)	No Reliable TRV Establishing Study Derive from dietary TRV																				1.4E+00	2.8E+00	
Great Horned Owl (diet)	Johnson et al 1960		Oral Diet	Chicken	4 weeks Subchronic duration		8 exposures 250, 500, 1000, 2000, 4000, 8000, 16,000, 32,000 ppm	Mortality	2,000	4,000	0.104 BW & FCNS - EPA 1988a	208	417	5	5	3	3	1	75	75	2.8E+00	5.6E+00	

NOAEL & LOAEL TRVs - BERYLLIUM

Receptor	Study	Chemical	Route	Study Test Species	Study Factors				NOAEL study conc (ppm)	LOAEL study conc (ppm)	Conversion Factor (kg food/ kg BW/day)	NOAEL dose (mg/kg-day)	LOAEL dose (mg/kg-day) <sup>1</sup>	Uncertainty Factors (UF)						Other	Total UF <sup>6</sup>		NOAEL TRV (mg/kg-day)	LOAEL TRV (mg/kg-day)
					Duration	N	Doses	Endpoint						Inter-species	Duration	Endpoint		NOAEL	LOAEL					
																NOAEL	LOAEL							
Deer Mouse (water)	Schroeder & Mitchener, 1975	Beryllium sulfate	Oral Water	Rat	Chronic; > 1year		1 dose of 5 ppm	Longevity; Weight loss	5.00		0.046 EPA, 1988a	5.00	NA	3	1	1	1	1	1	3	3	1.7E+00	5.0E+00	
Deer Mouse (diet)	No Reliable TRV Establishing Studies Found Derive from Water TRV <sup>2</sup>																					3.3E+00	1.0E+01	
Mink (water)	Schroeder & Mitchener, 1975	Beryllium sulfate	Oral Water	Rat	Chronic; > 1year		1 dose of 5 ppm	Longevity; Weight loss	5.00		0.046 EPA, 1988a	5.00	NA	3	1	1	1	1	1	3	3	1.7E+00	5.0E+00	
Mink (diet)	No Reliable TRV Establishing Studies Found Derive from Water TRV <sup>2</sup>																					3.3E+00	1.0E+01	
Meadow Vole (water)	Schroeder & Mitchener, 1975	Beryllium sulfate	Oral Water	Rat	Chronic; > 1year		1 dose of 5 ppm	Longevity; Weight loss	5.00		0.046 EPA, 1988a	5.00	NA	3	1	1	1	1	1	3	3	1.7E+00	5.0E+00	
Meadow Vole (diet)	No Reliable TRV Establishing Studies Found Derive from Water TRV <sup>2</sup>																					3.3E+00	1.0E+01	
Masked Shrew (water)	Schroeder & Mitchener, 1975	Beryllium sulfate	Oral Water	Rat	Chronic; > 1year		1 dose of 5 ppm	Longevity; Weight loss	5.00		0.046 EPA, 1988a	5.00	NA	3	1	1	1	1	1	3	3	1.7E+00	5.0E+00	
Masked Shrew (diet)	No Reliable TRV Establishing Studies Found Derive from Water TRV <sup>2</sup>																					3.3E+00	1.0E+01	
Red Fox (water)	Schroeder & Mitchener, 1975	Beryllium sulfate	Oral Water	Rat	Chronic; > 1year		1 dose of 5 ppm	Longevity; Weight loss	5.00		0.046 EPA, 1988a	5.00	NA	3	1	1	1	1	1	3	3	1.7E+00	5.0E+00	
Red Fox (diet)	No Reliable TRV Establishing Studies Found Derive from Water TRV <sup>2</sup>																					3.3E+00	1.0E+01	
American Robin (water)	No Reliable TRV Establishing Studies Found																					NA	NA	
American Robin (diet)	No Reliable TRV Establishing Studies Found																					NA	NA	
Cliff Swallow (water)	No Reliable TRV Establishing Studies Found																					NA	NA	
Cliff Swallow (diet)	No Reliable TRV Establishing Studies Found																					NA	NA	
American Kestrel (water)	No Reliable TRV Establishing Studies Found																					NA	NA	
American Kestrel (diet)	No Reliable TRV Establishing Studies Found																					NA	NA	
Belted Kingfisher (water)	No Reliable TRV Establishing Studies Found																					NA	NA	
Belted Kingfisher (diet)	No Reliable TRV Establishing Studies Found																					NA	NA	
American Dipper (water)	No Reliable TRV Establishing Studies Found																					NA	NA	
American Dipper (diet)	No Reliable TRV Establishing Studies Found																					NA	NA	
Great Horned Owl (water)	No Reliable TRV Establishing Studies Found																					NA	NA	
Great Horned Owl (diet)	No Reliable TRV Establishing Studies Found																					NA	NA	

NOAEL & LOAEL TRVs - CADMIUM

Receptor	Study	Chemical	Route	Study Test Species	Study Factors				NOAEL study conc (ppm)	LOAEL study conc (ppm)	Conversion Factor (kg food/ kg BW/day)	NOAEL dose (mg/kg-day)	LOAEL dose (mg/kg-day) <sup>1</sup>	Uncertainty Factors (UF)					Other	Total UF <sup>2</sup>		NOAEL TRV (mg/kg-day)	LOAEL TRV (mg/kg-day)
					Duration	N	Doses	Endpoint			Source			Inter-species	Duration	Endpoint		NOAEL		LOAEL			
																NOAEL	LOAEL						
Deer Mouse (water)	Schroeder & Mitchener, 1971	Soluble cadmium salts	Oral Water	Charles River CD Mice	Chronic; 3 generations	10 animals per dose group	1 exposure of 10 mg/L (0.1 ppm in diet)	Reproduction		10	0.25 ORNL 1996	NA	2.5	1	1	1	1	1	1	1	1	0.83	2.5
Deer Mouse (diet)	Wilson et al., 1941	Cadmium chloride	Oral Diet	Albino rats	Chronic; 100 days	4 to 6 animals per dose group	6 exposures (0 control, 31, 62, 125, 250, 500 ppm)	Growth	31	62	0.08 ORNL 1996	2.48	4.96	3	1	1	1	1	1	3	3	0.83	1.7
Mink (water)	Schroeder & Mitchener, 1971	Soluble cadmium salts	Oral Water	Charles River CD Mice	Chronic; 3 generations	10 animals per dose group	1 exposure of 10 mg/L (0.1 ppm in diet)	Reproduction		10	0.25 ORNL 1996	NA	2.5	5	1	1	1	1	1	5	5	0.17	0.5
Mink (diet)	Wilson et al., 1941	Cadmium chloride	Oral Diet	Albino rats	Chronic; 100 days	4 to 6 animals per dose group	6 exposures (0 control, 31, 62, 125, 250, 500 ppm)	Growth	31	62	0.08 ORNL 1996	2.48	4.96	5	1	1	1	1	1	5	5	0.50	1.0
Meadow Vole (water)	Schroeder & Mitchener, 1971	Soluble cadmium salts	Oral Water	Charles River CD Mice	Chronic; 3 generations	10 animals per dose group	1 exposure of 10 mg/L (0.1 ppm in diet)	Reproduction		10	0.25 ORNL 1996	NA	2.5	3	1	1	1	1	1	3	3	0.28	0.8
Meadow Vole (diet)	Wilson et al., 1941	Cadmium chloride	Oral Diet	Albino rats	Chronic; 100 days	4 to 6 animals per dose group	6 exposures (0 control, 31, 62, 125, 250, 500 ppm)	Growth	31	62	0.08 ORNL 1996	2.48	4.96	3	1	1	1	1	1	3	3	0.83	1.7
Masked Shrew (water)	Schroeder & Mitchener, 1971	Soluble cadmium salts	Oral Water	Charles River CD Mice	Chronic; 3 generations	10 animals per dose group	1 exposure of 10 mg/L (0.1 ppm in diet)	Reproduction		10	0.25 ORNL 1996	NA	2.5	5	1	1	1	1	1	5	5	0.17	0.5
Masked Shrew (diet)	Wilson et al., 1941	Cadmium chloride	Oral Diet	Albino rats	Chronic; 100 days	4 to 6 animals per dose group	6 exposures (0 control, 31, 62, 125, 250, 500 ppm)	Growth	31	62	0.08 ORNL 1996	2.48	4.96	5	1	1	1	1	1	5	5	0.50	1.0
Red Fox (water)	Schroeder & Mitchener, 1971	Soluble cadmium salts	Oral Water	Charles River CD Mice	Chronic; 3 generations	10 animals per dose group	1 exposure of 10 mg/L (0.1 ppm in diet)	Reproduction		10	0.25 ORNL 1996	NA	2.5	5	1	1	1	1	1	5	5	0.17	0.5
Red Fox (diet)	Wilson et al., 1941	Cadmium chloride	Oral Diet	Albino rats	Chronic; 100 days	4 to 6 animals per dose group	6 exposures (0 control, 31, 62, 125, 250, 500 ppm)	Growth	31	62	0.08 ORNL 1996	2.48	4.96	5	1	1	1	1	1	5	5	0.50	1.0
American Robin (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																					0.04	1.2
American Robin (diet)	White & Finley, 1978	Cadmium chloride	Oral Diet	Mallard	Chronic; 90 days	20 animals per dose group	4 exposure groups (0 control, 20, 200, 2000 ppm wet weight)	Reproduction	17.3	239	0.1 Measured in study	1.73	23.9	5	1	2	1	2	SMF	20	10	0.09	2.4
Cliff Swallow (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																					0.04	1.2
Cliff Swallow (diet)	White & Finley, 1978	Cadmium chloride	Oral Diet	Mallard	Chronic; 90 days	20 animals per dose group	4 exposure groups (0 control, 20, 200, 2000 ppm wet weight)	Reproduction	17.3	239	0.1 Measured in study	1.73	23.9	5	1	2	1	2	SMF	20	10	0.09	2.4
American Kestrel (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																					0.04	1.2
American Kestrel (diet)	White & Finley, 1978	Cadmium chloride	Oral Diet	Mallard	Chronic; 90 days	20 animals per dose group	4 exposure groups (0 control, 20, 200, 2000 ppm wet weight)	Reproduction	17.3	239	0.1 Measured in study	1.73	23.9	5	1	2	1	2	SMF	20	10	0.09	2.4
Belted Kingfisher (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																					0.04	1.2
Belted Kingfisher (diet)	White & Finley, 1978	Cadmium chloride	Oral Diet	Mallard	Chronic; 90 days	20 animals per dose group	4 exposure groups (0 control, 20, 200, 2000 ppm wet weight)	Reproduction	17.3	239	0.1 Measured in study	1.73	23.9	5	1	2	1	2	SMF	20	10	0.09	2.4
American Dipper (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																					0.04	1.2
American Dipper (diet)	White & Finley, 1978	Cadmium chloride	Oral Diet	Mallard	Chronic; 90 days	20 animals per dose group	4 exposure groups (0 control, 20, 200, 2000 ppm wet weight)	Reproduction	17.3	239	0.1 Measured in study	1.73	23.9	5	1	2	1	2	SMF	20	10	0.09	2.4
Great Horned Owl (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																					0.04	1.2
Great Horned Owl (diet)	White & Finley, 1978	Cadmium chloride	Oral Diet	Mallard	Chronic; 90 days	20 animals per dose group	4 exposure groups (0 control, 20, 200, 2000 ppm wet weight)	Reproduction	17.3	239	0.1 Measured in study	1.73	23.9	5	1	2	1	2	SMF	20	10	0.09	2.4

NOAEL & LOAEL TRVs - COPPER

Receptor	Study	Chemical	Route	Study Test Species	Study Factors			NOAEL study conc (ppm)	LOAEL study conc (ppm)	Source	Conversion Factor (kg food/kg BW/day)	NOAEL dose (mg/kg-day)	LOAEL dose (mg/kg-day)	Uncertainty Factors (UF)					Total UF <sup>5</sup>	NOAEL TRV (mg/kg-day)	LOAEL TRV (mg/kg-day)	
					Duration	N	Doses				Endpoint			Inter-species	Duration	Endpoint		Other				
																NOAEL	LOAEL					
Deer Mouse (water)	Hebert et al., 1993	Copper sulfate	Oral	B6C3F1 mice	Subchronic; 15 days	5 animals per sex per dose group	5 exposures (0, 300, 1000, 3000, 10000 mg/L)	Growth, Mortality		1	95	226	1	5	5	5	1	25	25	3.8E+00	9.0E+00	
		Water								None Required												
Deer Mouse (diet)	Hebert et al., 1993	Copper sulfate	Oral	B6C3F1 mice	Chronic; 92 days	10 animals per sex per dose group	6 exposures (0, 1000, 2000, 4000, 8000, 16000 mg/kg)	Reproduction, Growth		1	168	362	1	1	1	1	1	1	1	1.7E+02	3.6E+02	
		Diet								None Required												
Mink (water)	Aulerich et al., 1982	Copper sulfate	Oral	Mink	Chronic; 357 days	24 animals per dose group	5 exposures (60.5 control, 25, 50, 100, 200 mg/kg)	Reproduction (Reproductive success)	110.5	160.5	0.16	17.7	25.7	1	1	1	1	1	1	1.8E+01	2.6E+01	
		Water								USEPA, 1993												
Mink (diet)	No Reliable TRV Establishing Studies Found Derive from Water TRV <sup>2</sup>																			8.8E+00	1.3E+01	
Meadow Vole (water)	Hebert et al., 1993	Copper sulfate	Oral	B6C3F1 mice	Subchronic; 15 days	5 animals per sex per dose group	5 exposures (0, 300, 1000, 3000, 10000 mg/L)	Growth, Mortality		1	95	226	3	5	5	5	1	75	75	1.3E+00	3.0E+00	
		Water								None Required												
Meadow Vole (diet)	Hebert et al., 1993	Copper sulfate	Oral	B6C3F1 mice	Chronic; 92 days	10 animals per sex per dose group	6 exposures (0, 1000, 2000, 4000, 8000, 16000 mg/kg)	Reproduction, Growth		1	168	362	3	1	1	1	1	3	3	5.6E+01	1.2E+02	
		Diet								None Required												
Masked Shrew (water)	Hebert et al., 1993	Copper sulfate	Oral	B6C3F1 mice	Subchronic; 15 days	5 animals per sex per dose group	5 exposures (0, 300, 1000, 3000, 10000 mg/L)	Growth, Mortality		1	95	226	5	5	5	5	1	125	125	7.6E-01	1.8E+00	
		Water								None Required												
Masked Shrew (diet)	Hebert et al., 1993	Copper sulfate	Oral	B6C3F1 mice	Chronic; 92 days	10 animals per sex per dose group	6 exposures (0, 1000, 2000, 4000, 8000, 16000 mg/kg)	Reproduction, Growth		1	168	362	5	1	1	1	1	5	5	3.4E+01	7.2E+01	
		Diet								None Required												
Red Fox (water)	Aulerich et al., 1982	Copper sulfate	Oral	Mink	Chronic; 357 days	24 animals per dose group	5 exposures (60.5 control, 25, 50, 100, 200 mg/kg)	Reproduction (Reproductive success)	110.5	160.5	0.16	17.7	25.7	4	1	1	1	1	4	4	4.4E+00	6.4E+00
		Water								USEPA, 1993												
Red Fox (diet)	No Reliable TRV Establishing Studies Found Derive from Water TRV <sup>2</sup>																			2.2E+00	3.2E+00	
American Robin (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																			2.0E+00	3.0E+00	
American Robin (diet)	Jackson & Stevenson, 1981	Copper oxide	Oral	Chicken	Chronic; 40 weeks	22 animals per dose group	6 exposures (0 control, 150, 300, 450, 600, 750 ppm)	Reproduction	300	450	0.067	20.1	30.2	5	1	1	1	1	5	5	4.0E+00	6.0E+00
		Diet								Measured in study												
Cliff Swallow (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																			2.0E+00	3.0E+00	
Cliff Swallow (diet)	Jackson & Stevenson, 1981	Copper oxide	Oral	Chicken	Chronic; 40 weeks	22 animals per dose group	6 exposures (0 control, 150, 300, 450, 600, 750 ppm)	Reproduction	300	450	0.067	20.1	30.2	5	1	1	1	1	5	5	4.0E+00	6.0E+00
		Diet								Measured in study												
American Kestrel (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																			2.0E+00	3.0E+00	
American Kestrel (diet)	Jackson & Stevenson, 1981	Copper oxide	Oral	Chicken	Chronic; 40 weeks	22 animals per dose group	6 exposures (0 control, 150, 300, 450, 600, 750 ppm)	Reproduction	300	450	0.067	20.1	30.2	5	1	1	1	1	5	5	4.0E+00	6.0E+00
		Diet								Measured in study												
Belted Kingfisher (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																			2.0E+00	3.0E+00	
Belted Kingfisher (diet)	Jackson & Stevenson, 1981	Copper oxide	Oral	Chicken	Chronic; 40 weeks	22 animals per dose group	6 exposures (0 control, 150, 300, 450, 600, 750 ppm)	Reproduction	300	450	0.067	20.1	30.2	5	1	1	1	1	5	5	4.0E+00	6.0E+00
		Diet								Measured in study												
American Dipper (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																			2.0E+00	3.0E+00	
American Dipper (diet)	Jackson & Stevenson, 1981	Copper oxide	Oral	Chicken	Chronic; 40 weeks	22 animals per dose group	6 exposures (0 control, 150, 300, 450, 600, 750 ppm)	Reproduction	300	450	0.067	20.1	30.2	5	1	1	1	1	5	5	4.0E+00	6.0E+00
		Diet								Measured in study												
Great Horned Owl (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																			2.0E+00	3.0E+00	
Great Horned Owl (diet)	Jackson & Stevenson, 1981	Copper oxide	Oral	Chicken	Chronic; 40 weeks	22 animals per dose group	6 exposures (0 control, 150, 300, 450, 600, 750 ppm)	Reproduction	300	450	0.067	20.1	30.2	5	1	1	1	1	5	5	4.0E+00	6.0E+00
		Diet								Measured in study												

NOAEL & LOAEL TRVs - CHROMIUM

Receptor	Study	Chemical	Route	Study Test Species	Study Factors				NOAEL study conc (ppm)	LOAEL study conc (ppm)	Conversion Factor (kg food/ kg BW/day)	NOAEL dose (mg/kg-day)	LOAEL dose (mg/kg-day) <sup>1</sup>	Uncertainty Factors (UF)						Other	Total UF <sup>5</sup>		NOAEL TRV (mg/kg-day)	LOAEL TRV (mg/kg-day)	
					Duration	N	Doses	Endpoint						Inter-species	Duration	Endpoint		NOAEL	LOAEL						
																NOAEL	LOAEL								
Deer Mouse (water)	No Reliable TRV Establishing Study Derive from dietary TRV																							4.0E+02	1.2E+03
Deer Mouse (diet)	Ivankovic and Preussmann 1975	Chromium oxide Cr <sup>+3</sup>	Oral Diet	Rat	90 days & 2 years Chronic		3 exposures 1%, 2%, 5%	Reproduction; Longevity	50000		0.08 BW & FCNS - EPA 1988a	4000	NA	5	1	1	1	1	1	5	5	8.0E+02	2.4E+03		
Mink (water)	No Reliable TRV Establishing Study Derive from dietary TRV																							4.0E+02	1.2E+03
Mink (diet)	Ivankovic and Preussmann 1975	Chromium oxide Cr <sup>+3</sup>	Oral Diet	Rat	90 days & 2 years Chronic		3 exposures 1%, 2%, 5%	Reproduction; Longevity	50000		0.08 BW & FCNS - EPA 1988a	4000	NA	5	1	1	1	1	1	5	5	8.0E+02	2.4E+03		
Meadow Vole (water)	No Reliable TRV Establishing Study Derive from dietary TRV																							4.0E+02	1.2E+03
Meadow Vole (diet)	Ivankovic and Preussmann 1975	Chromium oxide Cr <sup>+3</sup>	Oral Diet	Rat	90 days & 2 years Chronic		3 exposures 1%, 2%, 5%	Reproduction; Longevity	50000		0.08 BW & FCNS - EPA 1988a	4000	NA	5	1	1	1	1	1	5	5	8.0E+02	2.4E+03		
Masked Shrew (water)	No Reliable TRV Establishing Study Derive from dietary TRV																							4.0E+02	1.2E+03
Masked Shrew (diet)	Ivankovic and Preussmann 1975	Chromium oxide Cr <sup>+3</sup>	Oral Diet	Rat	90 days & 2 years Chronic		3 exposures 1%, 2%, 5%	Reproduction; Longevity	50000		0.08 BW & FCNS - EPA 1988a	4000	NA	5	1	1	1	1	1	5	5	8.0E+02	2.4E+03		
Red Fox (water)	No Reliable TRV Establishing Study Derive from dietary TRV																							4.0E+02	1.2E+03
Red Fox (diet)	Ivankovic and Preussmann 1975	Chromium oxide Cr <sup>+3</sup>	Oral Diet	Rat	90 days & 2 years Chronic		3 exposures 1%, 2%, 5%	Reproduction; Longevity	50000		0.08 BW & FCNS - EPA 1988a	4000	NA	5	1	1	1	1	1	5	5	8.0E+02	2.4E+03		
American Robin (water)	No Reliable TRV Establishing Study Derive from dietary TRV																							1.0E-01	5.0E-01
American Robin (diet)	Haseltine et al. 1985	Chromium potassium sulfate Cr <sup>+3</sup>	Oral Diet	Black duck	10 months Critical lifestage		2 exposures 10 & 50 ppm	Reproduction	10	50	0.1 BW - Dunning 1984; FCNS - Heinz et al 1989	1.0	5.0	5	1	1	1	1	1	5	5	2.0E-01	1.0E+00		
Cliff Swallow (water)	No Reliable TRV Establishing Study Derive from dietary TRV																							1.0E-01	5.0E-01
Cliff Swallow (diet)	Haseltine et al. 1985	Chromium potassium sulfate Cr <sup>+3</sup>	Oral Diet	Black duck	10 months Critical lifestage		2 exposures 10 & 50 ppm	Reproduction	10	50	0.1 BW - Dunning 1984; FCNS - Heinz et al 1989	1.0	5.0	5	1	1	1	1	1	5	5	2.0E-01	1.0E+00		
American Kestrel (water)	No Reliable TRV Establishing Study Derive from dietary TRV																							1.0E-01	5.0E-01
American Kestrel (diet)	Haseltine et al. 1985	Chromium potassium sulfate Cr <sup>+3</sup>	Oral Diet	Black duck	10 months Critical lifestage		2 exposures 10 & 50 ppm	Reproduction	10	50	0.1 BW - Dunning 1984; FCNS - Heinz et al 1989	1.0	5.0	5	1	1	1	1	1	5	5	2.0E-01	1.0E+00		
Belted Kingfisher (water)	No Reliable TRV Establishing Study Derive from dietary TRV																							1.0E-01	5.0E-01
Belted Kingfisher (diet)	Haseltine et al. 1985	Chromium potassium sulfate Cr <sup>+3</sup>	Oral Diet	Black duck	10 months Critical lifestage		2 exposures 10 & 50 ppm	Reproduction	10	50	0.1 BW - Dunning 1984; FCNS - Heinz et al 1989	1.0	5.0	5	1	1	1	1	1	5	5	2.0E-01	1.0E+00		
American Dipper (water)	No Reliable TRV Establishing Study Derive from dietary TRV																							1.0E-01	5.0E-01
American Dipper (diet)	Haseltine et al. 1985	Chromium potassium sulfate Cr <sup>+3</sup>	Oral Diet	Black duck	10 months Critical lifestage		2 exposures 10 & 50 ppm	Reproduction	10	50	0.1 BW - Dunning 1984; FCNS - Heinz et al 1989	1.0	5.0	5	1	1	1	1	1	5	5	2.0E-01	1.0E+00		
Great Horned Owl (water)	No Reliable TRV Establishing Study Derive from dietary TRV																							1.0E-01	5.0E-01
Great Horned Owl (diet)	Haseltine et al. 1985	Chromium potassium sulfate Cr <sup>+3</sup>	Oral Diet	Black duck	10 months Critical lifestage		2 exposures 10 & 50 ppm	Reproduction	10	50	0.1 BW - Dunning 1984; FCNS - Heinz et al 1989	1.0	5.0	5	1	1	1	1	1	5	5	2.0E-01	1.0E+00		

NOAEL & LOAEL TRVs - CYANIDE

Receptor	Study	Chemical	Route	Study Test Species	Study Factors				NOAEL study conc (ppm)	LOAEL study conc (ppm)	Conversion Factor (kg food/ kg BW/day)	Source	NOAEL dose (mg/kg-day)	LOAEL dose (mg/kg-day) <sup>1</sup>	Uncertainty Factors (UF)				Other	Total UF <sup>5</sup>		NOAEL TRV (mg/kg-day)	LOAEL TRV (mg/kg-day)	
					Duration	N	Doses	Endpoint							Inter-species	Duration	Endpoint			NOAEL	LOAEL			
											NOAEL						LOAEL							
Deer Moose (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																						2.9E-01	8.6E-01
Deer Moose (diet)	Tewe & Maner, 1989	Cyanide	Oral Diet	Rat	Chronic Critical lifespan			Reproduction		68.7	1 None Required	NA	68.7	4	1	10	10	1	40	40			5.7E-01	1.7E+00
Mink (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																						2.3E-01	6.9E-01
Mink (diet)	Tewe & Maner, 1989	Cyanide	Oral Diet	Rat	Chronic Critical lifespan			Reproduction		68.7	1 None Required	NA	68.7	5	1	10	10	1	50	50			4.6E-01	1.4E+00
Meadow Vole (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																						2.3E-01	6.9E-01
Meadow Vole (diet)	Tewe & Maner, 1989	Cyanide	Oral Diet	Rat	Chronic Critical lifespan			Reproduction		68.7	1 None Required	NA	68.7	5	1	10	10	1	50	50			4.6E-01	1.4E+00
Masked Shrew (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																						2.3E-01	6.9E-01
Masked Shrew (diet)	Tewe & Maner, 1989	Cyanide	Oral Diet	Rat	Chronic Critical lifespan			Reproduction		68.7	1 None Required	NA	68.7	5	1	10	10	1	50	50			4.6E-01	1.4E+00
Red Fox (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																						2.3E-01	6.9E-01
Red Fox (diet)	Tewe & Maner, 1989	Cyanide	Oral Diet	Rat	Chronic Critical lifespan			Reproduction		68.7	1 None Required	NA	68.7	5	1	10	10	1	50	50			4.6E-01	1.4E+00
American Robin (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																						2.1E-01	6.2E-01
American Robin (diet)	Gomez et al., 1988	Cyanide	Oral Diet	Chicken	Subchronic Critical lifespan			Survival, Growth, and Systemic effects	6.18		1 None Required	6.18	NA	5	3	1	1	1	15	15			4.1E-01	1.2E+00
Cliff Swallow (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																						2.1E-01	6.2E-01
Cliff Swallow (diet)	Gomez et al., 1988	Cyanide	Oral Diet	Chicken	Subchronic Critical lifespan			Survival, Growth, and Systemic effects	6.18		1 None Required	6.18	NA	5	3	1	1	1	15	15			4.1E-01	1.2E+00
American Kestrel (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																						2.1E-01	6.2E-01
American Kestrel (diet)	Gomez et al., 1988	Cyanide	Oral Diet	Chicken	Subchronic Critical lifespan			Survival, Growth, and Systemic effects	6.18		1 None Required	6.18	NA	5	3	1	1	1	15	15			4.1E-01	1.2E+00
Belted Kingfisher (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																						2.1E-01	6.2E-01
Belted Kingfisher (diet)	Gomez et al., 1988	Cyanide	Oral Diet	Chicken	Subchronic Critical lifespan			Survival, Growth, and Systemic effects	6.18		1 None Required	6.18	NA	5	3	1	1	1	15	15			4.1E-01	1.2E+00
American Dipper (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																						2.1E-01	6.2E-01
American Dipper (diet)	Gomez et al., 1988	Cyanide	Oral Diet	Chicken	Subchronic Critical lifespan			Survival, Growth, and Systemic effects	6.18		1 None Required	6.18	NA	5	3	1	1	1	15	15			4.1E-01	1.2E+00
Great Horned Owl (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																						2.1E-01	6.2E-01
Great Horned Owl (diet)	Gomez et al., 1988	Cyanide	Oral Diet	Chicken	Subchronic Critical lifespan			Survival, Growth, and Systemic effects	6.18		1 None Required	6.18	NA	5	3	1	1	1	15	15			4.1E-01	1.2E+00

**NOAEL & LOAEL TRVs - LEAD**

Receptor	Study	Chemical	Route	Study Test Species	Study Factors				NOAEL study conc (ppm)	LOAEL study conc (ppm)	Conversion Factor (kg food/kg BW-day)	Source	NOAEL dose (mg/kg-day)	LOAEL dose (mg/kg-day) <sup>1</sup>	Uncertainty Factors (UF)						Other	Total UF <sup>2</sup>		NOAEL TRV (mg/kg-day)	LOAEL TRV (mg/kg-day)
					Duration	N	Doses	Endpoint							Inter-species	Duration	Endpoint		Total UF <sup>2</sup>	NOAEL TRV (mg/kg-day)		LOAEL TRV (mg/kg-day)			
											NOAEL	LOAEL													
Deer Mouse (water)	Schroeder & Mitchener, 1971	Soluble lead salt	Oral	Charles River CD Mice	Chronic; 3 generations	10 animals per dose group	1 exposure (25 mg/L + 0.2 ppm in diet)	Reproduction		25	0.25	NA	6.25	1	1	1	1	10 Effects seen in utero	10	10	2.1E-01	6.3E-01			
Deer Mouse (diet)	No Reliable TRV Establishing Studies Found Derive from Water TRV <sup>3</sup>		Water								Sax & Lewis, 1989											4.2E-01	1.3E+00		
Mink (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																					1.6E-01	3.1E-01		
Mink (diet)	Horwitt & Cowgill, 1938	Lead acetate	Oral	Dogs	Chronic; prenatal + 7 months	2 to 4 animals per dose group	4 exposures (2 control, 25, 50, 100 ppm)	Reproduction, Growth	52	102	0.024	1.25	2.45	4	1	1	1	1	4	4	3.1E-01	6.1E-01			
			Diet								ORNLI, 1996														
Meadow Vole (water)	Schroeder & Mitchener, 1971	Soluble lead salt	Oral	Charles River CD Mice	Chronic; 3 generations	10 animals per dose group	1 exposure (25 mg/L + 0.2 ppm in diet)	Reproduction		25	0.25	NA	6.25	3	1	1	1	10 Effects seen in utero	30	30	6.9E-02	2.1E-01			
			Water								Sax & Lewis, 1989														
Meadow Vole (diet)	No Reliable TRV Establishing Studies Found Derive from Water TRV <sup>3</sup>																					1.4E-01	4.3E-01		
Masked Shrew (water)	Schroeder & Mitchener, 1971	Soluble lead salt	Oral	Charles River CD Mice	Chronic; 3 generations	10 animals per dose group	1 exposure (25 mg/L + 0.2 ppm in diet)	Reproduction		25	0.25	NA	6.25	5	1	1	1	10 Effects seen in utero	50	50	4.2E-02	1.3E-01			
			Water								Sax & Lewis, 1989											8.3E-02	2.5E-01		
Masked Shrew (diet)	No Reliable TRV Establishing Studies Found Derive from Water TRV <sup>3</sup>																					8.3E-02	2.5E-01		
Red Fox (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																					2.1E-01	4.1E-01		
Red Fox (diet)	Horwitt & Cowgill, 1938	Lead acetate	Oral	Dogs	Chronic; prenatal + 7 months	2 to 4 animals per dose group	4 exposures (2 control, 25, 50, 100 ppm)	Reproduction, Growth	52	102	0.024	1.25	2.45	3	1	1	1	1	3	3	4.2E-01	8.2E-01			
			Diet								ORNLI, 1996														
American Robin (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																					4.4E-01	8.8E-01		
American Robin (diet)	Edens & Garlich, 1983	Lead acetate	Oral	Leghorn hens	Chronic; 10 weeks (during reproduction)	20 or 40 animals per dose group	3 or 5 exposures (Exp 1 - 0, 25, 50 ppm; Exp 2 - 0, 50, 100, 200, 400 ppm)	Reproduction (Egg production)	25	50	0.175	4.38	8.75	5	1	1	1	1	5	5	8.8E-01	1.8E+00			
			Diet								Sax & Lewis, 1989														
Chiff Swallow (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																					4.4E-01	8.8E-01		
Chiff Swallow (diet)	Edens & Garlich, 1983	Lead acetate	Oral	Leghorn hens	Chronic; 10 weeks (during reproduction)	20 or 40 animals per dose group	3 or 5 exposures (Exp 1 - 0, 25, 50 ppm; Exp 2 - 0, 50, 100, 200, 400 ppm)	Reproduction (Egg production)	25	50	0.175	4.38	8.75	5	1	1	1	1	5	5	8.8E-01	1.8E+00			
			Diet								Sax & Lewis, 1989														
American Kestrel (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																					4.4E-01	8.8E-01		
American Kestrel (diet)	Edens & Garlich, 1983	Lead acetate	Oral	Leghorn hens	Chronic; 10 weeks (during reproduction)	20 or 40 animals per dose group	3 or 5 exposures (Exp 1 - 0, 25, 50 ppm; Exp 2 - 0, 50, 100, 200, 400 ppm)	Reproduction (Egg production)	25	50	0.175	4.38	8.75	5	1	1	1	1	5	5	8.8E-01	1.8E+00			
			Diet								Sax & Lewis, 1989														
Belted Kingfisher (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																					4.4E-01	8.8E-01		
Belted Kingfisher (diet)	Edens & Garlich, 1983	Lead acetate	Oral	Leghorn hens	Chronic; 10 weeks (during reproduction)	20 or 40 animals per dose group	3 or 5 exposures (Exp 1 - 0, 25, 50 ppm; Exp 2 - 0, 50, 100, 200, 400 ppm)	Reproduction (Egg production)	25	50	0.175	4.38	8.75	5	1	1	1	1	5	5	8.8E-01	1.8E+00			
			Diet								Sax & Lewis, 1989														
American Dipper (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																					4.4E-01	8.8E-01		
American Dipper (diet)	Edens & Garlich, 1983	Lead acetate	Oral	Leghorn hens	Chronic; 10 weeks (during reproduction)	20 or 40 animals per dose group	3 or 5 exposures (Exp 1 - 0, 25, 50 ppm; Exp 2 - 0, 50, 100, 200, 400 ppm)	Reproduction (Egg production)	25	50	0.175	4.38	8.75	5	1	1	1	1	5	5	8.8E-01	1.8E+00			
			Diet								Sax & Lewis, 1989														
Great Horned Owl (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																					4.4E-01	8.8E-01		
Great Horned Owl (diet)	Edens & Garlich, 1983	Lead acetate	Oral	Leghorn hens	Chronic; 10 weeks (during reproduction)	20 or 40 animals per dose group	3 or 5 exposures (Exp 1 - 0, 25, 50 ppm; Exp 2 - 0, 50, 100, 200, 400 ppm)	Reproduction (Egg production)	25	50	0.175	4.38	8.75	5	1	1	1	1	5	5	8.8E-01	1.8E+00			
			Diet								Sax & Lewis, 1989														

**NOAEL & LOAEL TRVs - MANGANESE**

Receptor	Study	Chemical	Route	Study Test Species	Study Factors				NOAEL study conc (ppm)	LOAEL study conc (ppm)	Conversion Factor (kg food/ kg BW/day)	NOAEL dose (mg/kg-day)	LOAEL dose (mg/kg-day) <sup>1</sup>	Uncertainty Factors (UF)						Other	Total UF <sup>5</sup>		NOAEL TRV (mg/kg-day)	LOAEL TRV (mg/kg-day)	
					Duration	N	Doses	Endpoint						Inter-species	Duration	Endpoint		NOAEL	LOAEL						
											NOAEL					LOAEL									
Deer Mouse (water)	No Reliable TRV Establishing Study Derive from dietary TRV																							8.8E+00	2.8E+01
Deer Mouse (diet)	Laskey et al 1982	Manganese oxide	Oral Diet	Rat	224 days (through gestation) Critical lifespan		3 exposures 350, 1050, 3500 ppm (+ 50 ppm basal diet)	Reproduction	1100	3550	0.08 BW & FCNS - EPA 1988a	88	284	5	1	1	1	1	1	5	5			1.8E+01	5.7E+01
Mink (water)	No Reliable TRV Establishing Study Derive from dietary TRV																							8.8E+00	2.8E+01
Mink (diet)	Laskey et al 1982	Manganese oxide	Oral Diet	Rat	(through gestation) Critical lifespan		3 exposures 350, 1050, 3500 ppm (+ 50 ppm basal diet)	Reproduction	1100	3550	0.08 BW & FCNS - EPA 1988a	88	284	5	1	1	1	1	1	5	5			1.8E+01	5.7E+01
Meadow Vole (water)	No Reliable TRV Establishing Study Derive from dietary TRV																							8.8E+00	2.8E+01
Meadow Vole (diet)	Laskey et al 1982	Manganese oxide	Oral Diet	Rat	224 days (through gestation) Critical lifespan		3 exposures 350, 1050, 3500 ppm (+ 50 ppm basal diet)	Reproduction	1100	3550	0.08 BW & FCNS - EPA 1988a	88	284	5	1	1	1	1	1	5	5			1.8E+01	5.7E+01
Masked Shrew (water)	No Reliable TRV Establishing Study Derive from dietary TRV																							8.8E+00	2.8E+01
Masked Shrew (diet)	Laskey et al 1982	Manganese oxide	Oral Diet	Rat	224 days (through gestation) Critical lifespan		3 exposures 350, 1050, 3500 ppm (+ 50 ppm basal diet)	Reproduction	1100	3550	0.08 BW & FCNS - EPA 1988a	88	284	5	1	1	1	1	1	5	5			1.8E+01	5.7E+01
Red Fox (water)	No Reliable TRV Establishing Study Derive from dietary TRV																							8.8E+00	2.8E+01
Red Fox (diet)	Laskey et al 1982	Manganese oxide	Oral Diet	Rat	224 days (through gestation) Critical lifespan		3 exposures 350, 1050, 3500 ppm (+ 50 ppm basal diet)	Reproduction	1100	3550	0.08 BW & FCNS - EPA 1988a	88	284	5	1	1	1	1	1	5	5			1.8E+01	5.7E+01
American Robin (water)	No Reliable TRV Establishing Study Derive from dietary TRV																							3.3E+01	9.8E+01
American Robin (diet)	Laskey and Edens 1985	Manganese oxide	Oral Diet	Japanese quail	75 days Chronic exposure		1 exposure 5000 ppm (+56 ppm basal diet)	Growth; Aggressive behavior			1 None required	NA	977 Reported in study	5	1	1	1	1	1	5	5			6.5E+01	2.0E+02
Cliff Swallow (water)	No Reliable TRV Establishing Study Derive from dietary TRV																							3.3E+01	9.8E+01
Cliff Swallow (diet)	Laskey and Edens 1985	Manganese oxide	Oral Diet	Japanese quail	75 days Chronic exposure		1 exposure 5000 ppm (+56 ppm basal diet)	Growth; Aggressive behavior			1 None required	NA	977 Reported in study	5	1	1	1	1	1	5	5			6.5E+01	2.0E+02
American Kestrel (water)	No Reliable TRV Establishing Study Derive from dietary TRV																							3.3E+01	9.8E+01
American Kestrel (diet)	Laskey and Edens 1985	Manganese oxide	Oral Diet	Japanese quail	75 days Chronic exposure		1 exposure 5000 ppm (+56 ppm basal diet)	Growth; Aggressive behavior			1 None required	NA	977 Reported in study	5	1	1	1	1	1	5	5			6.5E+01	2.0E+02
Belted Kingfisher (water)	No Reliable TRV Establishing Study Derive from dietary TRV																							3.3E+01	9.8E+01
Belted Kingfisher (diet)	Laskey and Edens 1985	Manganese oxide	Oral Diet	Japanese quail	75 days Chronic exposure		1 exposure 5000 ppm (+56 ppm basal diet)	Growth; Aggressive behavior			1 None required	NA	977 Reported in study	5	1	1	1	1	1	5	5			6.5E+01	2.0E+02
American Dipper (water)	No Reliable TRV Establishing Study Derive from dietary TRV																							3.3E+01	9.8E+01
American Dipper (diet)	Laskey and Edens 1985	Manganese oxide	Oral Diet	Japanese quail	75 days Chronic exposure		1 exposure 5000 ppm (+56 ppm basal diet)	Growth; Aggressive behavior			1 None required	NA	977 Reported in study	5	1	1	1	1	1	5	5			6.5E+01	2.0E+02
Great Horned Owl (water)	No Reliable TRV Establishing Study Derive from dietary TRV																							3.3E+01	9.8E+01
Great Horned Owl (diet)	Laskey and Edens 1985	Manganese oxide	Oral Diet	Japanese quail	75 days Chronic exposure		1 exposure 5000 ppm (+56 ppm basal diet)	Growth; Aggressive behavior			1 None required	NA	977 Reported in study	5	1	1	1	1	1	5	5			6.5E+01	2.0E+02

**NOAEL & LOAEL TRVs - INORGANIC MERCURY**

Receptor	Study	Chemical	Route	Study Test Species	Study Factors			NOAEL study conc (ppm)	LOAEL study conc (ppm)	Conversion	NOAEL dose (mg/kg-day)	LOAEL dose (mg/kg-day) <sup>1</sup>	Uncertainty Factors (UF)							NOAEL TRV (mg/kg-day)	LOAEL TRV (mg/kg-day)			
					Duration	N	Doses			Endpoint			Source	Inter-species	Duration	Endpoint		Other	Total UF <sup>2</sup>					
																NOAEL	LOAEL		NOAEL			LOAEL		
Deer Mouse (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						3.30	9.9
Deer Mouse (diet)	Revis et al., 1989	Mercure sulfide	Oral	Mouse	Chronic; 20 months (included 6 month reprod.)		30 exposures (Highest dose = 13.2 mg/kg-day)	Reproduction, Mortality, Histology (liver, kidney)		1	13.2	NA	2	1	1	1	1	1	2	2		6.6	20	
		Diet	(Misc sp.)							None required														
Mink (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						6.69	2.1
Mink (diet)	Aulerich et al., 1974	Mercure chloride	Oral	Mink	Subchronic; 6 month Critical life stage (kit develop.)	15 animals per dose group	1 exposure (10 ppm)	Reproduction, Developmental	10	0.137	1.4	NA	1	1	1	1	1	1	1	1		1.4	4.1	
		Diet								Beavins & Aulerich, 1981														
Meadow Vole (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						2.20	6.6
Meadow Vole (diet)	Revis et al., 1989	Mercure sulfide	Oral	Mouse	Chronic; 20 months (included 6 month reprod.)		30 exposures (Highest dose = 13.2 mg/kg-day)	Reproduction, Mortality, Histology (liver, kidney)		1	13.2	NA	3	1	1	1	1	1	3	3		4.4	13	
		Diet	(Misc sp.)							None required														
Masked Shrew (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						1.32	4.0
Masked Shrew (diet)	Revis et al., 1989	Mercure sulfide	Oral	Mouse	Chronic; 20 months (included 6 month reprod.)		30 exposures (Highest dose = 13.2 mg/kg-day)	Reproduction, Mortality, Histology (liver, kidney)		1	13.2	NA	5	1	1	1	1	1	5	5		2.6	8	
		Diet	(Misc sp.)							None required														
Red Fox (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						0.17	0.5
Red Fox (diet)	Aulerich et al., 1974	Mercure chloride	Oral	Mink	Subchronic; 6 month Critical life stage (kit develop.)	15 animals per dose group	1 exposure (10 ppm)	Reproduction, Developmental	10	0.137	1.4	NA	4	1	1	1	1	1	4	4		0.3	1.0	
		Diet								Beavins & Aulerich, 1981														
American Robin (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						0.05	0.1
American Robin (diet)	Hill & Schaffner, 1976	Mercure chloride	Oral	Japanese quail	Chronic; 1 year Critical life stage (hatchling)		5 exposures (2, 4, 8, 16, 32 ppm)	Reproduction, Developmental	4	8	0.113	0.45	0.90	5	1	1	1	1	5	5		0.09	0.18	
		Diet								ORNL, 1996														
Cliff Swallow (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						0.05	0.1
Cliff Swallow (diet)	Hill & Schaffner, 1976	Mercure chloride	Oral	Japanese quail	Chronic; 1 year Critical life stage (hatchling)		5 exposures (2, 4, 8, 16, 32 ppm)	Reproduction, Developmental	4	8	0.113	0.45	0.90	5	1	1	1	1	5	5		0.09	0.18	
		Diet								ORNL, 1996														
American Kestrel (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						0.05	0.1
American Kestrel (diet)	Hill & Schaffner, 1976	Mercure chloride	Oral	Japanese quail	Chronic; 1 year Critical life stage (hatchling)		5 exposures (2, 4, 8, 16, 32 ppm)	Reproduction, Developmental	4	8	0.113	0.45	0.90	5	1	1	1	1	5	5		0.09	0.18	
		Diet								ORNL, 1996														
Belted Kingfisher (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						0.05	0.1
Belted Kingfisher (diet)	Hill & Schaffner, 1976	Mercure chloride	Oral	Japanese quail	Chronic; 1 year Critical life stage (hatchling)		5 exposures (2, 4, 8, 16, 32 ppm)	Reproduction, Developmental	4	8	0.113	0.45	0.90	5	1	1	1	1	5	5		0.09	0.18	
		Diet								ORNL, 1996														
American Dipper (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						0.05	0.1
American Dipper (diet)	Hill & Schaffner, 1976	Mercure chloride	Oral	Japanese quail	Chronic; 1 year Critical life stage (hatchling)		5 exposures (2, 4, 8, 16, 32 ppm)	Reproduction, Developmental	4	8	0.113	0.45	0.90	5	1	1	1	1	5	5		0.09	0.18	
		Diet								ORNL, 1996														
Great Horned Owl (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>4</sup>																						0.05	0.1
Great Horned Owl (diet)	Hill & Schaffner, 1976	Mercure chloride	Oral	Japanese quail	Chronic; 1 year Critical life stage (hatchling)		5 exposures (2, 4, 8, 16, 32 ppm)	Reproduction, Developmental	4	8	0.113	0.45	0.90	5	1	1	1	1	5	5		0.09	0.18	
		Diet								ORNL, 1996														

NOAEL & LOAEL TRVs - MOLYBDENUM

Receptor	Study	Chemical	Route	Study Test Species	Study Factors				NOAEL study conc (ppm)	LOAEL study conc (ppm)	Conversion Factor (kg food/kg BW/day)	Source	NOAEL dose (mg/kg-day) <sup>1</sup>	LOAEL dose (mg/kg-day) <sup>1</sup>	Uncertainty Factors (UF)						Total UF <sup>5</sup>	NOAEL TRV (mg/kg-day)	LOAEL TRV (mg/kg-day)
					Duration	N	Doses	Endpoint							Inter-species	Duration	Endpoint		Other				
																	NOAEL	LOAEL					
																				NOAEL			
Deer Mouse (water)	Schroeder & Mitchener, 1971	Molybdate (MoO <sub>4</sub> )	Oral Water	Mouse	Chronic; 3 generations	10 animals per dose group	1 exposure of 10 mg/L (0.45 ppm in diet)	Reproduction	0.45	10.45	0.25 BW & WCNS - EPA 1988a	0.1125	2.6	5	1	1	1	1	5	5	0.02	0.52	
Deer Mouse (diet)	No Reliable TRV Establishing Studies Found Derive from Water TRV																				0.01	0.26	
Mink (water)	Schroeder & Mitchener, 1971	Molybdate (MoO <sub>4</sub> )	Oral Water	Mouse	Chronic; 3 generations	10 animals per dose group	1 exposure of 10 mg/L (0.45 ppm in diet)	Reproduction	0.45	10.45	0.25 BW & WCNS - EPA 1988a	0.1125	2.6	5	1	1	1	1	5	5	0.02	0.52	
Mink (diet)	No Reliable TRV Establishing Studies Found Derive from Water TRV																				0.01	0.26	
Meadow Vole (water)	Schroeder & Mitchener, 1971	Molybdate (MoO <sub>4</sub> )	Oral Water	Mouse	Chronic; 3 generations	10 animals per dose group	1 exposure of 10 mg/L (0.45 ppm in diet)	Reproduction	0.45	10.45	0.25 BW & WCNS - EPA 1988a	0.1125	2.6	5	1	1	1	1	5	5	0.02	0.52	
Meadow Vole (diet)	No Reliable TRV Establishing Studies Found Derive from Water TRV																				0.01	0.26	
Masked Shrew (water)	Schroeder & Mitchener, 1971	Molybdate (MoO <sub>4</sub> )	Oral Water	Mouse	Chronic; 3 generations	10 animals per dose group	1 exposure of 10 mg/L (0.45 ppm in diet)	Reproduction	0.45	10.45	0.25 BW & WCNS - EPA 1988a	0.1125	2.6	5	1	1	1	1	5	5	0.02	0.52	
Masked Shrew (diet)	No Reliable TRV Establishing Studies Found Derive from Water TRV																				0.01	0.26	
Red Fox (water)	Schroeder & Mitchener, 1971	Molybdate (MoO <sub>4</sub> )	Oral Water	Mouse	Chronic; 3 generations	10 animals per dose group	1 exposure of 10 mg/L (0.45 ppm in diet)	Reproduction	0.45	10.45	0.25 BW & WCNS - EPA 1988a	0.1125	2.6	5	1	1	1	1	5	5	0.02	0.52	
Red Fox (diet)	No Reliable TRV Establishing Studies Found Derive from Water TRV																				0.01	0.26	
American Robin (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV																				1.18	3.53	
American Robin (diet)	Lepore & Miller, 1965	Sodium Molybdate	Oral Diet	Chicken	21 days thru reproduction Critical life stage		3 exposures (500, 1000, 2000 ppm in diet)	Reproduction		500	0.071 BW & FCNS - EPA 1988a	NA	35.33	5	1	1	1	1	5	5	2.36	7.07	
Chiff Swallow (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV																				1.18	3.53	
Chiff Swallow (diet)	Lepore & Miller, 1965	Sodium Molybdate	Oral Diet	Chicken	21 days thru reproduction Critical life stage		3 exposures (500, 1000, 2000 ppm in diet)	Reproduction		500	0.071 BW & FCNS - EPA 1988a	NA	35.33	5	1	1	1	1	5	5	2.36	7.07	
American Kestrel (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV																				1.18	3.53	
American Kestrel (diet)	Lepore & Miller, 1965	Sodium Molybdate	Oral Diet	Chicken	21 days thru reproduction Critical life stage		3 exposures (500, 1000, 2000 ppm in diet)	Reproduction		500	0.071 BW & FCNS - EPA 1988a	NA	35.33	5	1	1	1	1	5	5	2.36	7.07	
Belted Kingfisher (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV																				1.18	3.53	
Belted Kingfisher (diet)	Lepore & Miller, 1965	Sodium Molybdate	Oral Diet	Chicken	21 days thru reproduction Critical life stage		3 exposures (500, 1000, 2000 ppm in diet)	Reproduction		500	0.071 BW & FCNS - EPA 1988a	NA	35.33	5	1	1	1	1	5	5	2.36	7.07	
American Dipper (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV																				1.18	3.53	
American Dipper (diet)	Lepore & Miller, 1965	Sodium Molybdate	Oral Diet	Chicken	21 days thru reproduction Critical life stage		3 exposures (500, 1000, 2000 ppm in diet)	Reproduction		500	0.071 BW & FCNS - EPA 1988a	NA	35.33	5	1	1	1	1	5	5	2.36	7.07	
Great Horned Owl (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV																				1.18	3.53	
Great Horned Owl (diet)	Lepore & Miller, 1965	Sodium Molybdate	Oral Diet	Chicken	21 days thru reproduction Critical life stage		3 exposures (500, 1000, 2000 ppm in diet)	Reproduction		500	0.071 BW & FCNS - EPA 1988a	NA	35.33	5	1	1	1	1	5	5	2.36	7.07	

NOAEL & LOAEL TRVs - NICKEL

Receptor	Study	Chemical	Route	Study Test Species	Study Factors				NOAEL study conc (ppm)	LOAEL study conc (ppm)	Conversion Factor (kg food/kg BW/day)	Source	NOAEL dose (mg/kg-day)	LOAEL dose (mg/kg-day) <sup>1</sup>	Uncertainty Factors (UF)							NOAEL TRV (mg/kg-day)	LOAEL TRV (mg/kg-day)
					Duration	N	Doses	Endpoint							Inter-species	Duration	Endpoint		Other	Total UF <sup>2</sup>			
																	NOAEL	LOAEL		NOAEL	LOAEL		
Deer Mouse (water)	Smith et al., 1993	Nickel chloride	Oral	Long-Evans rats	Chronic; 4 month (11 wks pre-gestation)	34 females per dose grp	4 exposures (control, XX, XX, XX ppm)	Reproduction		1.3	1	None Required	NA	1.30	4	1	1	1	1	4	4	1.1E-01	3.3E-01
Deer Mouse (diet)	Ambrose et al., 1976	Nickel sulfate hexahydrate	Oral	Wistar rats	Chronic; 3 generations	60 animals per dose grp	4 exposures (control, 500, 1000, 2500 ppm)	Reproduction	500	1,000	0.08 ORNL, 1996	40	80	4	1	1	1	1	1	4	4	1.0E+01	2.0E+01
Mink (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																					3.0E+00	7.5E+00
Mink (diet)	Ambrose et al., 1976	Nickel sulfate hexahydrate	Oral	Dog (beagle)	Chronic; 2 years	6 animals per dose grp	4 exposures (control, 500, 1000, 2500 ppm)	Growth	1,000	2,500	0.024 ORNL, 1996	24	60	4	1	1	1	1	1	4	4	6.0E+00	1.5E+01
Meadow Vole (water)	Smith et al., 1993	Nickel chloride	Oral	Long-Evans rats	Chronic; 4 month (11 wks pre-gestation)	34 females per dose grp	4 exposures (control, XX, XX, XX ppm)	Reproduction		1.3	1	None Required	NA	1.30	4	1	1	1	1	4	4	1.1E-01	3.3E-01
Meadow Vole (diet)	Ambrose et al., 1976	Nickel sulfate hexahydrate	Oral	Wistar rats	Chronic; 3 generations	60 animals per dose grp	4 exposures (control, 500, 1000, 2500 ppm)	Reproduction	500	1,000	0.08 ORNL, 1996	40	80	4	1	1	1	1	1	4	4	1.0E+01	2.0E+01
Masked Shrew (water)	Smith et al., 1993	Nickel chloride	Oral	Long-Evans rats	Chronic; 4 month (11 wks pre-gestation)	34 females per dose grp	4 exposures (control, XX, XX, XX ppm)	Reproduction		1.3	1	None Required	NA	1.30	4	1	1	1	1	4	4	1.1E-01	3.3E-01
Masked Shrew (diet)	Ambrose et al., 1976	Nickel sulfate hexahydrate	Oral	Wistar rats	Chronic; 3 generations	60 animals per dose grp	4 exposures (control, 500, 1000, 2500 ppm)	Reproduction	500	1,000	0.08 ORNL, 1996	40	80	4	1	1	1	1	1	4	4	1.0E+01	2.0E+01
Red Fox (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																					3.0E+00	7.5E+00
Red Fox (diet)	Ambrose et al., 1976	Nickel sulfate hexahydrate	Oral	Dog (beagle)	Chronic; 2 years	6 animals per dose grp	4 exposures (control, 500, 1000, 2500 ppm)	Growth	1,000	2,500	0.024 ORNL, 1996	24	60	4	1	1	1	1	1	4	4	6.0E+00	1.5E+01
American Robin (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																					2.7E+00	4.0E+00
American Robin (diet)	Cain & Pafford, 1981	Nickel sulfate	Oral	Mallard	Subchronic; 90 days	36 animals per dose grp	4 exposures (control, XX, 800, 1200 ppm)	Growth (Mortality?)	800	1,200	0.10 Measured in study & Heinz et al., 1989	80	120	5	3	1	1	1	1	15	15	5.3E+00	8.0E+00
Cliff Swallow (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																					2.7E+00	4.0E+00
Cliff Swallow (diet)	Cain & Pafford, 1981	Nickel sulfate	Oral	Mallard	Subchronic; 90 days	36 animals per dose grp	4 exposures (control, XX, 800, 1200 ppm)	Growth (Mortality?)	800	1,200	0.10 Measured in study & Heinz et al., 1989	80	120	5	3	1	1	1	1	15	15	5.3E+00	8.0E+00
American Kestrel (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																					2.7E+00	4.0E+00
American Kestrel (diet)	Cain & Pafford, 1981	Nickel sulfate	Oral	Mallard	Subchronic; 90 days	36 animals per dose grp	4 exposures (control, XX, 800, 1200 ppm)	Growth (Mortality?)	800	1,200	0.10 Measured in study & Heinz et al., 1989	80	120	5	3	1	1	1	1	15	15	5.3E+00	8.0E+00
Belted Kingfisher (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																					2.7E+00	4.0E+00
Belted Kingfisher (diet)	Cain & Pafford, 1981	Nickel sulfate	Oral	Mallard	Subchronic; 90 days	36 animals per dose grp	4 exposures (control, XX, 800, 1200 ppm)	Growth (Mortality?)	800	1,200	0.10 Measured in study & Heinz et al., 1989	80	120	5	3	1	1	1	1	15	15	5.3E+00	8.0E+00
American Dipper (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																					2.7E+00	4.0E+00
American Dipper (diet)	Cain & Pafford, 1981	Nickel sulfate	Oral	Mallard	Subchronic; 90 days	36 animals per dose grp	4 exposures (control, XX, 800, 1200 ppm)	Growth (Mortality?)	800	1,200	0.10 Measured in study & Heinz et al., 1989	80	120	5	3	1	1	1	1	15	15	5.3E+00	8.0E+00
Great Horned Owl (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																					2.7E+00	4.0E+00
Great Horned Owl (diet)	Cain & Pafford, 1981	Nickel sulfate	Oral	Mallard	Subchronic; 90 days	36 animals per dose grp	4 exposures (control, XX, 800, 1200 ppm)	Growth (Mortality?)	800	1,200	0.10 Measured in study & Heinz et al., 1989	80	120	5	3	1	1	1	1	15	15	5.3E+00	8.0E+00

NOAEL & LOAEL TRVs - SELENIUM

Receptor	Study	Chemical	Route	Study Test Species	Study Factors				NOAEL study conc (ppm)	LOAEL study conc (ppm)	Conversion Factor (kg food/kg BW/day)	NOAEL dose (mg/kg-day)	LOAEL dose (mg/kg-day) <sup>1</sup>	Uncertainty Factors (UF)						Other	Total UF <sup>5</sup>		NOAEL TRV (mg/kg-day)	LOAEL TRV (mg/kg-day)
					Duration	N	Doses	Endpoint			Source			Inter-species	Duration	Endpoint		NOAEL	LOAEL					
																NOAEL	LOAEL							
Deer Mouse (water)	Rosenfeld & Beath 1954	Potassium selenate	Oral Water	Rat	1 year (2 generations) Critical lifespan		3 exposures 1.5, 2.5, 7.5 mg/L	Reproduction	1.5	2.5	0.13 BW & WCNS - EPA 1988a	0.20	0.33	3	1	1	1	1	3	3	6.6E-02	1.1E-01		
Deer Mouse (diet)	No Reliable TRV Establishing Study Derive from water TRV																				1.3E-01	2.2E-01		
Mink (water)	Rosenfeld & Beath 1954	Potassium selenate	Oral Water	Rat	1 year (2 generations) Critical lifespan		3 exposures 1.5, 2.5, 7.5 mg/L	Reproduction	1.5	2.5	0.13 BW & WCNS - EPA 1988a	0.20	0.33	5	1	1	1	1	5	5	3.9E-02	6.6E-02		
Mink (diet)	No Reliable TRV Establishing Study Derive from water TRV																				7.9E-02	1.3E-01		
Meadow Vole (water)	Rosenfeld & Beath 1954	Potassium selenate	Oral Water	Rat	1 year (2 generations) Critical lifespan		3 exposures 1.5, 2.5, 7.5 mg/L	Reproduction	1.5	2.5	0.13 BW & WCNS - EPA 1988a	0.20	0.33	3	1	1	1	1	3	3	6.6E-02	1.1E-01		
Meadow Vole (diet)	No Reliable TRV Establishing Study Derive from water TRV																				1.3E-01	2.2E-01		
Masked Shrew (water)	Rosenfeld & Beath 1954	Potassium selenate	Oral Water	Rat	1 year (2 generations) Critical lifespan		3 exposures 1.5, 2.5, 7.5 mg/L	Reproduction	1.5	2.5	0.13 BW & WCNS - EPA 1988a	0.20	0.33	5	1	1	1	1	5	5	3.9E-02	6.6E-02		
Masked Shrew (diet)	No Reliable TRV Establishing Study Derive from water TRV																				7.9E-02	1.3E-01		
Red Fox (water)	Rosenfeld & Beath 1954	Potassium selenate	Oral Water	Rat	1 year (2 generations) Critical lifespan		3 exposures 1.5, 2.5, 7.5 mg/L	Reproduction	1.5	2.5	0.13 BW & WCNS - EPA 1988a	0.20	0.33	5	1	1	1	1	5	5	3.9E-02	6.6E-02		
Red Fox (diet)	No Reliable TRV Establishing Study Derive from water TRV																				7.9E-02	1.3E-01		
American Robin (water)	No Reliable TRV Establishing Study Derive from dietary TRV																				5.0E-02	1.0E-01		
American Robin (diet)	Heinz et al 1987	Sodium selenite	Oral Diet	Mallard	78 days Critical lifespan		5 exposures 1, 5, 10, 25, 100 ppm	Reproduction	5	10	0.10 Measured in study	0.5	1.0	5	1	1	1	1	5	5	1.0E-01	2.0E-01		
Cliff Swallow (water)	No Reliable TRV Establishing Study Derive from dietary TRV																				5.0E-02	1.0E-01		
Cliff Swallow (diet)	Heinz et al 1987	Sodium selenite	Oral Diet	Mallard	78 days Critical lifespan		5 exposures 1, 5, 10, 25, 100 ppm	Reproduction	5	10	0.10 Measured in study	0.5	1.0	5	1	1	1	1	5	5	1.0E-01	2.0E-01		
American Kestrel (water)	No Reliable TRV Establishing Study Derive from dietary TRV																				5.0E-02	1.0E-01		
American Kestrel (diet)	Heinz et al 1987	Sodium selenite	Oral Diet	Mallard	78 days Critical lifespan		5 exposures 1, 5, 10, 25, 100 ppm	Reproduction	5	10	0.10 Measured in study	0.5	1.0	5	1	1	1	1	5	5	1.0E-01	2.0E-01		
Belted Kingfisher (water)	No Reliable TRV Establishing Study Derive from dietary TRV																				5.0E-02	1.0E-01		
Belted Kingfisher (diet)	Heinz et al 1987	Sodium selenite	Oral Diet	Mallard	78 days Critical lifespan		5 exposures 1, 5, 10, 25, 100 ppm	Reproduction	5	10	0.10 Measured in study	0.5	1.0	5	1	1	1	1	5	5	1.0E-01	2.0E-01		
American Dipper (water)	No Reliable TRV Establishing Study Derive from dietary TRV																				5.0E-02	1.0E-01		
American Dipper (diet)	Heinz et al 1987	Sodium selenite	Oral Diet	Mallard	78 days Critical lifespan		5 exposures 1, 5, 10, 25, 100 ppm	Reproduction	5	10	0.10 Measured in study	0.5	1.0	5	1	1	1	1	5	5	1.0E-01	2.0E-01		
Great Horned Owl (water)	No Reliable TRV Establishing Study Derive from dietary TRV																				5.0E-02	1.0E-01		
Great Horned Owl (diet)	Heinz et al 1987	Sodium selenite	Oral Diet	Mallard	78 days Critical lifespan		5 exposures 1, 5, 10, 25, 100 ppm	Reproduction	5	10	0.10 Measured in study	0.5	1.0	5	1	1	1	1	5	5	1.0E-01	2.0E-01		

NOAEL & LOAEL TRVs - THALLIUM

Receptor	Study	Chemical	Route	Study Test Species	Study Factors				NOAEL study conc (ppm)	LOAEL study conc (ppm)	Conversion Factor (kg food/ kg BW/day)	NOAEL dose (mg/kg-day)	LOAEL dose (mg/kg-day) <sup>1</sup>	Uncertainty Factors (UF)					NOAEL TRV (mg/kg-day)	LOAEL TRV (mg/kg-day)		
					Duration	N	Doses	Endpoint			Source			Inter-species	Duration	Endpoint		Other			Total UF <sup>5</sup>	
																NOAEL	LOAEL				NOAEL	LOAEL
Deer Mouse (water)	Formigli et al 1986	Thallium sulfate	Oral	Rat	60 days Subchronic		1 exposure	Reproduction		10	0.007	NA	0.074	3	5	1	1	1	15	15	1.6E-03	4.9E-03
			Water				10 ppm	Male testicular function			Measured in study				Subchronic						3.3E-03	9.9E-03
Deer Mouse (diet)	No Reliable TRV Establishing Study Derive from water TRV																				3.3E-03	9.9E-03
Mink (water)	Formigli et al 1986	Thallium sulfate	Oral	Rat	60 days Subchronic		1 exposure	Reproduction		10	0.007	NA	0.074	5	5	1	1	1	25	25	9.9E-04	3.0E-03
			Water				10 ppm	Male testicular function			Measured in study				Subchronic							
Mink (diet)	No Reliable TRV Establishing Study Derive from water TRV																				2.0E-03	5.9E-03
Masked Shrew (water)	Formigli et al 1986	Thallium sulfate	Oral	Rat	60 days Subchronic		1 exposure	Reproduction		10	0.007	NA	0.074	5	5	1	1	1	25	25	9.9E-04	3.0E-03
			Water				10 ppm	Male testicular function			Measured in study				Subchronic							
Masked Shrew (diet)	No Reliable TRV Establishing Study Derive from water TRV																				2.0E-03	5.9E-03
Red Fox (water)	Formigli et al 1986	Thallium sulfate	Oral	Rat	60 days Subchronic		1 exposure	Reproduction		10	0.007	NA	0.074	5	5	1	1	1	25	25	9.9E-04	3.0E-03
			Water				10 ppm	Male testicular function			Measured in study				Subchronic							
Red Fox (diet)	No Reliable TRV Establishing Study Derive from water TRV																				2.0E-03	5.9E-03
American Robin (water)	No Reliable TRV Establishing Study																				NA	NA
American Robin (diet)	No Reliable TRV Establishing Study																				NA	NA
American Kestrel (water)	No Reliable TRV Establishing Study																				NA	NA
American Kestrel (diet)	No Reliable TRV Establishing Study																				NA	NA
Belted Kingfisher (water)	No Reliable TRV Establishing Study																				NA	NA
Belted Kingfisher (diet)	No Reliable TRV Establishing Study																				NA	NA
American Dipper (water)	No Reliable TRV Establishing Study																				NA	NA
American Dipper (diet)	No Reliable TRV Establishing Study																				NA	NA
Great Horned Owl (water)	No Reliable TRV Establishing Study																				NA	NA
Great Horned Owl (diet)	No Reliable TRV Establishing Study																				NA	NA

NOEL & LOEL TRVs - VANADIUM

Receptor	Study	Chemical	Route	Study Test Species	Study Factors				NOAEL study conc (ppm)	LOAEL study conc (ppm)	Conversion Factor (kg food/ kg BW/day)	NOAEL dose (mg/kg-day)	LOAEL dose (mg/kg-day) <sup>1</sup>	Uncertainty Factors (UF)				Other	Total UF <sup>5</sup>		NOAEL TRV (mg/kg-day)	LOAEL TRV (mg/kg-day)
					Duration	N	Doses	Endpoint			Source			Inter-species	Duration	Endpoint			NOAEL	LOAEL		
																NOAEL	LOAEL					
Deer Mouse (water)	Domingo et al 1986	Sodium metavanadate	Oral	Rat	60 days pre-gestation through lactation; Chronic		3 exposures	Reproduction		5	1	NA	5.0	3	1	1	1	1	3	3	5.6E-01	1.7E+00
			Gavage				5, 10, 20 mg/kg-day				None required										1.1E+00	3.3E+00
Deer Mouse (diet)	No Reliable TRV Establishing Study Derive from water TRV																				1.1E+00	3.3E+00
Mink (water)	Domingo et al 1986	Sodium metavanadate	Oral	Rat	60 days pre-gestation through lactation; Chronic		3 exposures	Reproduction		5	1	NA	5.0	5	1	1	1	1	5	5	3.3E-01	1.0E+00
			Gavage				5, 10, 20 mg/kg-day				None required										3.3E-01	1.0E+00
Mink (diet)	No Reliable TRV Establishing Study Derive from water TRV																				6.7E-01	2.0E+00
Masked Shrew (water)	Domingo et al 1986	Sodium metavanadate	Oral	Rat	60 days pre-gestation through lactation; Chronic		3 exposures	Reproduction		5	1	NA	5.0	5	1	1	1	1	5	5	3.3E-01	1.0E+00
			Gavage				5, 10, 20 mg/kg-day				None required										3.3E-01	1.0E+00
Masked Shrew (diet)	No Reliable TRV Establishing Study Derive from water TRV																				6.7E-01	2.0E+00
Red Fox (water)	Domingo et al 1986	Sodium metavanadate	Oral	Rat	60 days pre-gestation through lactation; Chronic		3 exposures	Reproduction		5	1	NA	5.0	5	1	1	1	1	5	5	3.3E-01	1.0E+00
			Gavage				5, 10, 20 mg/kg-day				None required										3.3E-01	1.0E+00
Red Fox (diet)	No Reliable TRV Establishing Study Derive from water TRV																				6.7E-01	2.0E+00
American Robin (water)	No Reliable TRV Establishing Study Derive from dietary TRV																				1.1E+00	3.4E+00
American Robin (diet)	White & Dieter 1978	Vanadyl sulfate	Oral Diet	Mallard	12 weeks Chronic		3 exposures 2.84, 10.36, 110 ppm	Mortality; Body weight	110		0.10 Measured in study	11.38	NA	5	1	1	1	1	5	5	2.3E+00	6.8E+00
American Kestrel (water)	No Reliable TRV Establishing Study Derive from dietary TRV																				1.1E+00	3.4E+00
American Kestrel (diet)	White & Dieter 1978	Vanadyl sulfate	Oral Diet	Mallard	12 weeks Chronic		3 exposures 2.84, 10.36, 110 ppm	Mortality; Body weight	110		0.10 Measured in study	11.38	NA	5	1	1	1	1	5	5	2.3E+00	6.8E+00
Belted Kingfisher (water)	No Reliable TRV Establishing Study Derive from dietary TRV																				1.1E+00	3.4E+00
Belted Kingfisher (diet)	White & Dieter 1978	Vanadyl sulfate	Oral Diet	Mallard	12 weeks Chronic		3 exposures 2.84, 10.36, 110 ppm	Mortality; Body weight	110		0.10 Measured in study	11.38	NA	5	1	1	1	1	5	5	2.3E+00	6.8E+00
American Dipper (water)	No Reliable TRV Establishing Study Derive from dietary TRV																				1.1E+00	3.4E+00
American Dipper (diet)	White & Dieter 1978	Vanadyl sulfate	Oral Diet	Mallard	12 weeks Chronic		3 exposures 2.84, 10.36, 110 ppm	Mortality; Body weight	110		0.10 Measured in study	11.38	NA	5	1	1	1	1	5	5	2.3E+00	6.8E+00
Great Horned Owl (water)	No Reliable TRV Establishing Study Derive from dietary TRV																				1.1E+00	3.4E+00
Great Horned Owl (diet)	White & Dieter 1978	Vanadyl sulfate	Oral Diet	Mallard	12 weeks Chronic		3 exposures 2.84, 10.36, 110 ppm	Mortality; Body weight	110		0.10 Measured in study	11.38	NA	5	1	1	1	1	5	5	2.3E+00	6.8E+00

NOAEL & LOAEL TRVs - ZINC

Receptor	Study	Chemical	Route	Study Test Species	Study Factors				NOAEL study conc (ppm)	LOAEL study conc (ppm)	Conversion Factor (kg food/kg BW/day)	NOAEL dose (mg/kg-day)	LOAEL dose (mg/kg-day) <sup>1</sup>	Uncertainty Factors (UF)						NOAEL TRV (mg/kg-day)	LOAEL TRV (mg/kg-day)		
					Duration	N	Doses	Endpoint						Inter-species	Duration	Endpoint		Other	Total UF <sup>2</sup>				
											NOAEL					LOAEL	NOAEL		LOAEL				
Deer Mouse (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																					20	40
Deer Mouse (diet)	Schlicker & Cox, 1968	Zinc oxide	Oral Diet	Sprague-Dawley rat	Chronic	10 animals per dose group	2 exposures (0.2%, 0.4% ZnO)	Fetal Development, Growth	2000	4000	0.06 Sax & Lewis, 1989	120	240	3	1	1	1	1	3	3		40	80
Mink (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																					155.5	466.5
Mink (diet)	Aulerich et al., 1991	Zinc sulfate	Oral Diet	Mink	Chronic	12 animals per dose group	4 exposures (0.500, 1000, 1500 ppm)	Survivability, Growth			1 None required	311 ave. of male & female kits	NA	1	1	1	1	1	1	1	1	311	933
Meadow Vole (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																					20	40
Meadow Vole (diet)	Schlicker & Cox, 1968	Zinc oxide	Oral Diet	Sprague-Dawley rat	Chronic	10 animals per dose group	2 exposures (0.2%, 0.4% ZnO)	Fetal Development, Growth	2000	4000	0.06 Sax & Lewis, 1989	120	240	3	1	1	1	1	3	3		40	80
Masked Shrew (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																					12	24
Masked Shrew (diet)	Schlicker & Cox, 1968	Zinc oxide	Oral Diet	Sprague-Dawley rat	Chronic	10 animals per dose group	2 exposures (0.2%, 0.4% ZnO)	Fetal Development, Growth	2000	4000	0.06 Sax & Lewis, 1989	120	240	5	1	1	1	1	5	5		24	48
Red Fox (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																					38.9	116.6
Red Fox (diet)	Aulerich et al., 1991	Zinc sulfate	Oral Diet	Mink	Chronic	12 animals per dose group	4 exposures (0.500, 1000, 1500 ppm)	Survivability, Growth			1 None required	311 ave. of male & female kits	NA	4	1	1	1	1	4	4		78	233
American Robin (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																					13	39
American Robin (diet)	Stahl et al., 1989	Zinc sulfate	Oral Diet	White leghorn hen	Chronic; 44 weeks Critical life stage		3 exposures (28 control, 20, 200, 2000 ppm)	Reproduction	2,028		0.0646 Measured in study (NOAEL group)	131	NA	5	1	1	1	1	5	5		26	79
Cliff Swallow (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																					13	39
Cliff Swallow (diet)	Stahl et al., 1989	Zinc sulfate	Oral Diet	White leghorn hen	Chronic; 44 weeks Critical life stage		3 exposures (28 control, 20, 200, 2000 ppm)	Reproduction	2,028		0.0646 Measured in study (NOAEL group)	131	NA	5	1	1	1	1	5	5		26	79
American Kestrel (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																					13	39
American Kestrel (diet)	Stahl et al., 1989	Zinc sulfate	Oral Diet	White leghorn hen	Chronic; 44 weeks Critical life stage		3 exposures (28 control, 20, 200, 2000 ppm)	Reproduction	2,028		0.0646 Measured in study (NOAEL group)	131	NA	5	1	1	1	1	5	5		26	79
Belted Kingfisher (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																					13	39
Belted Kingfisher (diet)	Stahl et al., 1989	Zinc sulfate	Oral Diet	White leghorn hen	Chronic; 44 weeks Critical life stage		3 exposures (28 control, 20, 200, 2000 ppm)	Reproduction	2,028		0.0646 Measured in study (NOAEL group)	131	NA	5	1	1	1	1	5	5		26	79
American Dipper (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																					13	39
American Dipper (diet)	Stahl et al., 1989	Zinc sulfate	Oral Diet	White leghorn hen	Chronic; 44 weeks Critical life stage		3 exposures (28 control, 20, 200, 2000 ppm)	Reproduction	2,028		0.0646 Measured in study (NOAEL group)	131	NA	5	1	1	1	1	5	5		26	79
Great Horned Owl (water)	No Reliable TRV Establishing Studies Found Derive from Dietary TRV <sup>3</sup>																					13	39
Great Horned Owl (diet)	Stahl et al., 1989	Zinc sulfate	Oral Diet	White leghorn hen	Chronic; 44 weeks Critical life stage		3 exposures (28 control, 20, 200, 2000 ppm)	Reproduction	2,028		0.0646 Measured in study (NOAEL group)	131	NA	5	1	1	1	1	5	5		26	79

## References for Wildlife Toxicity Reference Values (TRVs)

- Aulerich, R.J., R.K. Ringer, and J. Iwamoto. 1974. Effects of Dietary Mercury on Mink. *Arch. Environ. Contam. Toxicol.* 2:43-51.
- Aulerich, R.L., R.K. Ringer, M.R. Bleavins, and A. Napolitano. 1982. Effects of supplemental dietary copper on growth, reproductive performance, and kit survival of standard dark mink and the acute toxicity of copper and mink. *Journal of Animal Science.* 55(2):337-343.
- Aulerich, R.J., S.J. Bursian, R.H. Poppenga, W.E. Braselton, and T.P. Mullaney. 1991. Toleration of high concentrations of dietary zinc by mink. *Journal of Veterinary Diagnostic Investigations* 3:232-237.
- Bleavins, M.R. and R.J. Aulerich. 1981. Feed consumption and food passage time in mink (Mustela vison) and European ferrets (Mustela putorius furo). *Lab. Anim. Sci.* 31:268-269.
- Byron, W.R., G.W. Bierbower, J.B. Brouwer, and W.H. Hansen. 1967. Pathologic changes in rats and dogs from two-year feeding of sodium arsenite or sodium arsenate. *Toxicology and Applied Pharmacology* 10: 132-147.
- Camardese, M.B., D.J. Hoffman, L.J. LeCaptain, and G.W. Pendleton. 1990. Effect of arsenate on growth and physiology in mallard ducklings. *Environmental Toxicology and Chemistry* 9:785-795.
- Domingo, J.L., J.L. Paternain, J.M. Llobet, and J. Corbella. 1986. Effects of vanadium on reproduction, gestation, parturition and lactation rats upon oral administration. *Life Sci.* 39:819-824.
- Dunning, J.B. Jr. 1993. *CRC Handbook of Avian Body Masses*. CRC Press, FL
- Edens, F.W. and J.D. Garlich. 1983. Lead-induced egg production decrease in Leghorn and Japanese Quail hens. *Poultry Science* 62:1757-1763.
- Golub, M.S., M.E. Gershwin, J.M. Donald, S. Negri, and C.L. Keen. 1987. Maternal and Developmental Toxicity of Chronic Aluminum Exposure in Mice. *Fundamental and Applied Toxicology.* 8: 346-357.
- Haseltine, S.D., L. Sileo, D.J. Hoffman, and B.D. Mulhern. 1985. Effects of chromium on reproduction and growth on black ducks.
- Heinz, G.H., D.J. Hoffman, A.J. Krynitsky, and D.M.G. Weller. 1987. Reproduction in mallards fed selenium. *Environ. Toxicol. Chem.* 6:423-433.

- Heinz, G.H., D.J. Hoffman, and L.G. Gold. 1989. Impaired reproduction of mallards fed an organic form of selenium. *J. Wildl. Mgmt.* 53:418-428.
- Hebert, C.D., M.R. Elwell, G.S. Travlos, C.J. Fitz, and J.R. Bucher. 1993. Subchronic toxicity of cupric sulfate administered in drinking water and feed to rats and mice. *Fundamental and Applied Toxicology* 21(4):461-475.
- Hill, E.F. and C.S. Shaffner. 1976. Sexual maturation and productivity of Japanese quail fed graded concentrations of mercuric chloride. *Poultry Science*. 55: 1449-1459
- Horwitt, M.K. and G.R. Cowgill. 1938. The effects of ingested lead on the organism . Studies on the rat. *Journal of Pharmacology and Experimental Therapy* 66:300-310.
- Ivankovic, S. and R. Preussmann. 1975. Absence of toxic and carcinogenic effects after administration of high doses of chromic oxide pigment in subacute and long-term feeding experiments in rats. *Fd. Cosmet. Toxicol.* 13:347-351.
- Jackson, N. and M.H. Stevenson. 1981. Identification if the component responsible for the effects of added dietary copper sulfate in the female domestic fowl. *Journal of the Science of Food and Agriculture* 32:1047-1056.
- Johnson, D., Jr., A.L. Mehring, Jr., and H.W. Titus. 1960. Tolerance of chickens for barium. *Proc. Soc. Exp. Biol. Med.* 104:436-438.
- Laskey, J. W., G.L. Rehnberg, J. F. Hein, and S.d. Carter. 1982. Effects of chronic manganese (Mn<sub>3</sub>O<sub>4</sub>) exposure on selected reproductive parameters in rats. *J. Toxicol. Environ. Health.* 9:677-687.
- Laskey, J.W., and F.W. Edens. 1985. Effects of chronic high-level manganese exposure on male behavior in the Japanese Quail (*Cotirnix coturnix japonica*). *Poultry Sci.* 64:579-584.
- Mollenhauer, H.H., D.E. Corrier, D.E. Clark, M.F. Hare, and M.H. Elissaide. 1985. Effects of Dietary Cobalt on Testicular Structure. *Virchows. Arch. B.* 49:241-248
- ORNL, 1996. Opresko, D.M., B.E. Sample, and G.W. Suter II. Toxicological Benchmarks for Wildlife: 1996 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. Es/ER/TM-86/R3.
- Perry, H.M., E.F. Perry, M.N. Eranger, and S.J. Kopp. 1983. Cardiovascular effects of chronic barium ingestion. In: Proc. 17<sup>th</sup> Ann. Conf. Trace Substances in Environ. Health, vol. 17. U. of Missouri Press, Columbia, MO.

- Revis N., Holdsworth G., Bingham G., King A., Elmore J., 1989. An assessment of health risk associated with mercury in soil and sediment from East Fork Poplar Creek, Oak Ridge, Tennessee. Oak Ridge Research Institute, final Report 58, pp.
- Rosenfeld, I. And O.A. Beath. 1954. Effect of selenium on reproduction in rats. *Proc. Soc. Exp. Biol. Med.* 87:295-297.
- Sax, I. and R. Lewis. 1989. *Dangerous Properties of Industrial Materials*. 7<sup>th</sup> ed., Vol. III, Van Nostrand Reinhold, NY.
- Schlicker, S.A. and D.H. Cox. 1968. Maternal dietary zinc and development and zinc, iron, and copper content of the rat fetus. *Journal of Nutrition* 95:287-294.
- Schroeder, H.A. and M. Mitchener. 1971. Toxic effects of trace elements on the reproduction of mice and rats. *Archives of Environmental Health* 23:102-106.
- Sparling, D.W. 1990. Acid Precipitation and Food Quality: Inhibition of Growth and Survival in Black Ducks and Mallards by Dietary Aluminum, Calcium and Phosphorus. *Archives of Environmental Contamination and Toxicology*. 19: 457-463.
- Stahl, J.L., M.E. Cook, M.L. Sunde, and J.L. Greger. 1989. Enhanced humoral immunity in progeny chicks fed practical diets supplemented with zinc. *Applied Agricultural Research* 4:86-89.
- Stanley, T.R., Jr., J.W. Spann, G.J. Smith, and R. Rosscoe. 1994. Main and interactive effects of arsenic and selenium on mallard reproduction and duckling growth and survival. *Archives of Environmental Contamination and Toxicology* 26:444-451.
- United States Environmental Protection Agency (USEPA). 1988a. *Recommendations for and documentation of biological values for use in risk assessment*. Environmental Criteria and Assessment Office, Cincinnati, OH. EPA/600/6-87/008.
- United States Environmental Protection Agency (USEPA). 1993. *Wildlife Exposure Factors Handbook*. Volume I. U.S. Environmental Protection Agency, Office of Research and Development. EPA/600/R-93/187a. December 1993.
- White, D.H. and M.T. Finley. 1978. Uptake and retention of dietary cadmium in mallard ducks. *Environmental Research* 17:53-59.
- Wilson, R.H., F. Deeds, and A.J. Cox, Jr. 1941. Effects of continued cadmium feeding. *Journal of Pharmacology and Experimental Therapy* 71:222-235.

## **APPENDIX L**

### **DETAILED RISK CALCULATIONS FOR WILDLIFE RECEPTORS OF CONCERN**

# APPENDIX L

## American Dipper

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART A: HQ VALUES CALCULATED USING NOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
WWC - Reach A	Aluminum	NA	7E-01	NA	NA	NA	NA	NA	7E-02	NA	8E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	4E-03	2E-01	NA	NA	NA	NA	NA	1E-01	NA	3E-01
	Barium	NA	4E-02	NA	NA	NA	NA	NA	9E-03	NA	5E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	8E-03	NA	NA	NA	NA	NA	2E-03	NA	1E-02
	Chromium	NA	6E-02	NA	NA	NA	NA	NA	6E-03	NA	7E-02
	Copper	NA	7E-03	NA	NA	NA	NA	NA	1E-03	NA	8E-03
	Lead	NA	1E-02	NA	NA	NA	NA	NA	4E-04	NA	1E-02
	Manganese	NA	1E-02	NA	NA	NA	NA	NA	2E-02	NA	3E-02
	Mercury	NA	1E-03	NA	NA	NA	NA	NA	NA	NA	1E-03
	Molybdenum	NA	5E-04	NA	NA	NA	NA	NA	NA	NA	5E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	8E-03	NA	NA	NA	NA	NA	6E-04	NA	8E-03
	Zinc	1E-02	3E-03	NA	NA	NA	NA	NA	3E-03	NA	2E-02
WWC - Reach B	Aluminum	NA	8E-01	NA	NA	NA	NA	NA	3E-02	NA	8E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	6E-03	4E-01	NA	NA	NA	NA	NA	1E-02	NA	4E-01
	Barium	NA	1E-01	NA	NA	NA	NA	NA	1E-03	NA	1E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	1E-02	NA	NA	NA	NA	NA	2E-04	NA	1E-02
	Chromium	NA	9E-02	NA	NA	NA	NA	NA	6E-03	NA	1E-01
	Copper	NA	1E-02	NA	NA	NA	NA	NA	2E-03	NA	2E-02
	Lead	NA	2E-01	NA	NA	NA	NA	NA	3E-04	NA	2E-01
	Manganese	NA	1E-02	NA	NA	NA	NA	NA	7E-04	NA	1E-02
	Mercury	NA	2E-03	NA	NA	NA	NA	NA	NA	NA	2E-03
	Molybdenum	NA	1E-03	NA	NA	NA	NA	NA	NA	NA	1E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	1E-02	NA	NA	NA	NA	NA	3E-04	NA	1E-02
	Zinc	4E-02	5E-03	NA	NA	NA	NA	NA	1E-03	NA	5E-02
WWC - Reach C	Aluminum	NA	6E-01	NA	NA	NA	NA	NA	4E-02	NA	7E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	3E-02	1E+00	NA	NA	NA	NA	NA	4E-02	NA	1E+00
	Barium	NA	5E-02	NA	NA	NA	NA	NA	2E-03	NA	5E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	1E-02	NA	NA	NA	NA	NA	5E-04	NA	1E-02
	Chromium	NA	5E-02	NA	NA	NA	NA	NA	6E-03	NA	6E-02
	Copper	NA	2E-02	NA	NA	NA	NA	NA	2E-03	NA	2E-02
	Lead	NA	3E-02	NA	NA	NA	NA	NA	7E-04	NA	3E-02
	Manganese	NA	9E-03	NA	NA	NA	NA	NA	7E-04	NA	9E-03
	Mercury	NA	5E-03	NA	NA	NA	NA	NA	4E-04	NA	5E-03
	Molybdenum	NA	8E-04	NA	NA	NA	NA	NA	NA	NA	8E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	9E-03	NA	NA	NA	NA	NA	4E-04	NA	9E-03
	Zinc	9E-04	3E-03	NA	NA	NA	NA	NA	1E-03	NA	5E-03
WWC - Reach D	Aluminum	NA	9E-01	NA	NA	NA	NA	NA	4E-02	NA	1E+00
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	5E-02	6E-01	NA	NA	NA	NA	NA	3E-02	NA	7E-01
	Barium	NA	4E-02	NA	NA	NA	NA	NA	2E-03	NA	5E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	9E-03	NA	NA	NA	NA	NA	4E-04	NA	1E-02
	Chromium	NA	6E-02	NA	NA	NA	NA	NA	6E-03	NA	6E-02
	Copper	NA	6E-03	NA	NA	NA	NA	NA	1E-03	NA	7E-03
	Lead	NA	1E-02	NA	NA	NA	NA	NA	4E-04	NA	1E-02
	Manganese	NA	8E-03	NA	NA	NA	NA	NA	3E-03	NA	1E-02
	Mercury	NA	2E-03	NA	NA	NA	NA	NA	8E-04	NA	3E-03
	Molybdenum	NA	5E-04	NA	NA	NA	NA	NA	NA	NA	5E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	1E-02	NA	NA	NA	NA	NA	6E-04	NA	1E-02
	Zinc	3E-03	2E-03	NA	NA	NA	NA	NA	1E-03	NA	6E-03

# APPENDIX L

## American Dipper

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART A: HQ VALUES CALCULATED USING NOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
BFR - Reach A	Aluminum	NA	5E-01	NA	NA	NA	NA	NA	NA	NA	5E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	2E-03	1E-02	NA	NA	NA	NA	NA	NA	NA	1E-02
	Barium	NA	6E-02	NA	NA	NA	NA	NA	NA	NA	6E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	1E-02	NA	NA	NA	NA	NA	NA	NA	1E-02
	Chromium	NA	3E-02	NA	NA	NA	NA	NA	NA	NA	3E-02
	Copper	NA	3E-03	NA	NA	NA	NA	NA	NA	NA	3E-03
	Lead	NA	8E-03	NA	NA	NA	NA	NA	NA	NA	8E-03
	Manganese	NA	6E-03	NA	NA	NA	NA	NA	NA	NA	6E-03
	Mercury	NA	3E-04	NA	NA	NA	NA	NA	NA	NA	3E-04
	Molybdenum	NA	1E-03	NA	NA	NA	NA	NA	NA	NA	1E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	1E-02	NA	NA	NA	NA	NA	NA	NA	1E-02
	Zinc	6E-05	2E-03	NA	NA	NA	NA	NA	NA	NA	2E-03
BFR - Reach B	Aluminum	NA	6E-01	NA	NA	NA	NA	NA	2E-02	NA	7E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	7E-04	1E+00	NA	NA	NA	NA	NA	3E-03	NA	1E+00
	Barium	NA	4E-02	NA	NA	NA	NA	NA	1E-03	NA	4E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	9E-03	NA	NA	NA	NA	NA	2E-04	NA	1E-02
	Chromium	NA	4E-02	NA	NA	NA	NA	NA	5E-03	NA	4E-02
	Copper	NA	5E-03	NA	NA	NA	NA	NA	1E-03	NA	6E-03
	Lead	NA	1E-02	NA	NA	NA	NA	NA	2E-04	NA	1E-02
	Manganese	NA	8E-03	NA	NA	NA	NA	NA	3E-03	NA	1E-02
	Mercury	NA	1E-03	NA	NA	NA	NA	NA	NA	NA	1E-03
	Molybdenum	NA	6E-04	NA	NA	NA	NA	NA	NA	NA	6E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	1E-02	NA	NA	NA	NA	NA	4E-04	NA	1E-02
	Zinc	6E-05	2E-03	NA	NA	NA	NA	NA	9E-04	NA	3E-03
SPC	Aluminum	NA	3E-01	NA	NA	NA	NA	NA	2E-02	NA	3E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	7E-04	1E-02	NA	NA	NA	NA	NA	9E-04	NA	1E-02
	Barium	NA	3E-02	NA	NA	NA	NA	NA	2E-03	NA	3E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	3E-03	NA	NA	NA	NA	NA	8E-05	NA	3E-03
	Chromium	NA	2E-02	NA	NA	NA	NA	NA	5E-03	NA	3E-02
	Copper	NA	1E-03	NA	NA	NA	NA	NA	6E-04	NA	2E-03
	Lead	NA	1E-02	NA	NA	NA	NA	NA	4E-04	NA	1E-02
	Manganese	NA	2E-03	NA	NA	NA	NA	NA	2E-04	NA	2E-03
	Mercury	NA	3E-04	NA	NA	NA	NA	NA	4E-04	NA	6E-04
	Molybdenum	NA	2E-05	NA	NA	NA	NA	NA	NA	NA	2E-05
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	3E-03	NA	NA	NA	NA	NA	3E-04	NA	3E-03
	Zinc	6E-05	6E-04	NA	NA	NA	NA	NA	1E-03	NA	2E-03

# APPENDIX L

## American Dipper

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART B: HQ VALUES CALCULATED USING LOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
WWC - Reach A	Aluminum	NA	1E-01	NA	NA	NA	NA	NA	1E-02	NA	2E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	4E-04	2E-02	NA	NA	NA	NA	NA	1E-02	NA	3E-02
	Barium	NA	2E-02	NA	NA	NA	NA	NA	5E-03	NA	2E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	3E-04	NA	NA	NA	NA	NA	7E-05	NA	4E-04
	Chromium	NA	1E-02	NA	NA	NA	NA	NA	1E-03	NA	1E-02
	Copper	NA	4E-03	NA	NA	NA	NA	NA	7E-04	NA	5E-03
	Lead	NA	5E-03	NA	NA	NA	NA	NA	2E-04	NA	6E-03
	Manganese	NA	4E-03	NA	NA	NA	NA	NA	5E-03	NA	9E-03
	Mercury	NA	7E-04	NA	NA	NA	NA	NA	NA	NA	7E-04
	Molybdenum	NA	2E-04	NA	NA	NA	NA	NA	NA	NA	2E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	3E-03	NA	NA	NA	NA	NA	2E-04	NA	3E-03
	Zinc	5E-03	1E-03	NA	NA	NA	NA	NA	1E-03	NA	7E-03
WWC - Reach B	Aluminum	NA	2E-01	NA	NA	NA	NA	NA	6E-03	NA	2E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	7E-04	4E-02	NA	NA	NA	NA	NA	1E-03	NA	5E-02
	Barium	NA	5E-02	NA	NA	NA	NA	NA	6E-04	NA	5E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	5E-04	NA	NA	NA	NA	NA	9E-06	NA	5E-04
	Chromium	NA	2E-02	NA	NA	NA	NA	NA	1E-03	NA	2E-02
	Copper	NA	1E-02	NA	NA	NA	NA	NA	1E-03	NA	1E-02
	Lead	NA	9E-02	NA	NA	NA	NA	NA	1E-04	NA	9E-02
	Manganese	NA	4E-03	NA	NA	NA	NA	NA	2E-04	NA	4E-03
	Mercury	NA	1E-03	NA	NA	NA	NA	NA	NA	NA	1E-03
	Molybdenum	NA	3E-04	NA	NA	NA	NA	NA	NA	NA	3E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	4E-03	NA	NA	NA	NA	NA	1E-04	NA	4E-03
	Zinc	1E-02	2E-03	NA	NA	NA	NA	NA	4E-04	NA	2E-02
WWC - Reach C	Aluminum	NA	1E-01	NA	NA	NA	NA	NA	7E-03	NA	1E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	3E-03	1E-01	NA	NA	NA	NA	NA	5E-03	NA	1E-01
	Barium	NA	2E-02	NA	NA	NA	NA	NA	9E-04	NA	2E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	4E-04	NA	NA	NA	NA	NA	2E-05	NA	4E-04
	Chromium	NA	1E-02	NA	NA	NA	NA	NA	1E-03	NA	1E-02
	Copper	NA	1E-02	NA	NA	NA	NA	NA	1E-03	NA	1E-02
	Lead	NA	2E-02	NA	NA	NA	NA	NA	3E-04	NA	2E-02
	Manganese	NA	3E-03	NA	NA	NA	NA	NA	2E-04	NA	3E-03
	Mercury	NA	2E-03	NA	NA	NA	NA	NA	2E-04	NA	2E-03
	Molybdenum	NA	3E-04	NA	NA	NA	NA	NA	NA	NA	3E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	3E-03	NA	NA	NA	NA	NA	1E-04	NA	3E-03
	Zinc	3E-04	1E-03	NA	NA	NA	NA	NA	5E-04	NA	2E-03
WWC - Reach D	Aluminum	NA	2E-01	NA	NA	NA	NA	NA	8E-03	NA	2E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	5E-03	7E-02	NA	NA	NA	NA	NA	4E-03	NA	8E-02
	Barium	NA	2E-02	NA	NA	NA	NA	NA	1E-03	NA	2E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	3E-04	NA	NA	NA	NA	NA	1E-05	NA	4E-04
	Chromium	NA	1E-02	NA	NA	NA	NA	NA	1E-03	NA	1E-02
	Copper	NA	4E-03	NA	NA	NA	NA	NA	9E-04	NA	5E-03
	Lead	NA	6E-03	NA	NA	NA	NA	NA	2E-04	NA	6E-03
	Manganese	NA	3E-03	NA	NA	NA	NA	NA	1E-03	NA	4E-03
	Mercury	NA	1E-03	NA	NA	NA	NA	NA	4E-04	NA	1E-03
	Molybdenum	NA	2E-04	NA	NA	NA	NA	NA	NA	NA	2E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	5E-03	NA	NA	NA	NA	NA	2E-04	NA	5E-03
	Zinc	1E-03	8E-04	NA	NA	NA	NA	NA	4E-04	NA	2E-03

# APPENDIX L

## American Dipper

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART B: HQ VALUES CALCULATED USING LOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
BFR - Reach A	Aluminum	NA	1E-01	NA	NA	NA	NA	NA	NA	NA	1E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	3E-04	1E-03	NA	NA	NA	NA	NA	NA	NA	1E-03
	Barium	NA	3E-02	NA	NA	NA	NA	NA	NA	NA	3E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	5E-04	NA	NA	NA	NA	NA	NA	NA	5E-04
	Chromium	NA	6E-03	NA	NA	NA	NA	NA	NA	NA	6E-03
	Copper	NA	2E-03	NA	NA	NA	NA	NA	NA	NA	2E-03
	Lead	NA	4E-03	NA	NA	NA	NA	NA	NA	NA	4E-03
	Manganese	NA	2E-03	NA	NA	NA	NA	NA	NA	NA	2E-03
	Mercury	NA	1E-04	NA	NA	NA	NA	NA	NA	NA	1E-04
	Molybdenum	NA	4E-04	NA	NA	NA	NA	NA	NA	NA	4E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	4E-03	NA	NA	NA	NA	NA	NA	NA	4E-03
	Zinc	2E-05	6E-04	NA	NA	NA	NA	NA	NA	NA	6E-04
BFR - Reach B	Aluminum	NA	1E-01	NA	NA	NA	NA	NA	4E-03	NA	1E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	9E-05	1E-01	NA	NA	NA	NA	NA	3E-04	NA	1E-01
	Barium	NA	2E-02	NA	NA	NA	NA	NA	6E-04	NA	2E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	3E-04	NA	NA	NA	NA	NA	9E-06	NA	4E-04
	Chromium	NA	7E-03	NA	NA	NA	NA	NA	1E-03	NA	8E-03
	Copper	NA	3E-03	NA	NA	NA	NA	NA	7E-04	NA	4E-03
	Lead	NA	7E-03	NA	NA	NA	NA	NA	1E-04	NA	7E-03
	Manganese	NA	3E-03	NA	NA	NA	NA	NA	1E-03	NA	4E-03
	Mercury	NA	6E-04	NA	NA	NA	NA	NA	NA	NA	6E-04
	Molybdenum	NA	2E-04	NA	NA	NA	NA	NA	NA	NA	2E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	4E-03	NA	NA	NA	NA	NA	1E-04	NA	4E-03
	Zinc	2E-05	6E-04	NA	NA	NA	NA	NA	3E-04	NA	9E-04
SPC	Aluminum	NA	6E-02	NA	NA	NA	NA	NA	3E-03	NA	6E-02
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	9E-05	1E-03	NA	NA	NA	NA	NA	1E-04	NA	1E-03
	Barium	NA	2E-02	NA	NA	NA	NA	NA	8E-04	NA	2E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	1E-04	NA	NA	NA	NA	NA	3E-06	NA	1E-04
	Chromium	NA	4E-03	NA	NA	NA	NA	NA	1E-03	NA	5E-03
	Copper	NA	7E-04	NA	NA	NA	NA	NA	4E-04	NA	1E-03
	Lead	NA	5E-03	NA	NA	NA	NA	NA	2E-04	NA	5E-03
	Manganese	NA	6E-04	NA	NA	NA	NA	NA	8E-05	NA	7E-04
	Mercury	NA	1E-04	NA	NA	NA	NA	NA	2E-04	NA	3E-04
	Molybdenum	NA	7E-06	NA	NA	NA	NA	NA	NA	NA	7E-06
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	1E-03	NA	NA	NA	NA	NA	9E-05	NA	1E-03
	Zinc	2E-05	2E-04	NA	NA	NA	NA	NA	3E-04	NA	5E-04

# APPENDIX L

## Mink

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART A: HQ VALUES CALCULATED USING NOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
WWC - Reach A	Aluminum	NA	1E+00	NA	NA	4E-02	NA	NA	4E-02	NA	1E+00
	Antimony	NA	2E-01	NA	NA	2E-02	NA	NA	3E-03	NA	2E-01
	Arsenic	4E-03	6E-01	NA	NA	9E-04	NA	NA	1E-01	NA	7E-01
	Barium	NA	3E-02	NA	NA	1E-03	NA	NA	3E-03	NA	4E-02
	Beryllium	NA	NA	NA	NA	2E-06	NA	NA	NA	NA	2E-06
	Cadmium	NA	9E-04	NA	NA	5E-05	NA	NA	7E-05	NA	1E-03
	Chromium	NA	1E-05	NA	NA	8E-07	NA	NA	3E-07	NA	1E-05
	Copper	NA	2E-03	NA	NA	1E-04	NA	NA	1E-04	NA	2E-03
	Lead	NA	2E-02	NA	NA	5E-04	NA	NA	2E-04	NA	2E-02
	Manganese	NA	3E-02	NA	NA	2E-04	NA	NA	1E-02	NA	4E-02
	Mercury	NA	6E-05	NA	NA	4E-07	NA	NA	NA	NA	6E-05
	Molybdenum	NA	6E-02	NA	NA	NA	NA	NA	NA	NA	6E-02
	Thallium	NA	NA	NA	NA	5E-04	NA	NA	NA	NA	5E-04
	Vanadium	NA	2E-02	NA	NA	1E-04	NA	NA	4E-04	NA	2E-02
	Zinc	8E-04	2E-04	NA	NA	3E-05	NA	NA	5E-05	NA	1E-03
WWC - Reach B	Aluminum	NA	2E+00	NA	NA	NA	NA	NA	2E-02	NA	2E+00
	Antimony	NA	1E-01	NA	NA	NA	NA	NA	3E-04	NA	1E-01
	Arsenic	7E-03	1E+00	NA	NA	NA	NA	NA	1E-02	NA	1E+00
	Barium	NA	9E-02	NA	NA	NA	NA	NA	4E-04	NA	9E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	1E-03	NA	NA	NA	NA	NA	9E-06	NA	1E-03
	Chromium	NA	2E-05	NA	NA	NA	NA	NA	3E-07	NA	2E-05
	Copper	NA	4E-03	NA	NA	NA	NA	NA	2E-04	NA	4E-03
	Lead	NA	3E-01	NA	NA	NA	NA	NA	2E-04	NA	3E-01
	Manganese	NA	3E-02	NA	NA	NA	NA	NA	5E-04	NA	3E-02
	Mercury	NA	1E-04	NA	NA	NA	NA	NA	NA	NA	1E-04
	Molybdenum	NA	1E-01	NA	NA	NA	NA	NA	NA	NA	1E-01
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	3E-02	NA	NA	NA	NA	NA	2E-04	NA	3E-02
	Zinc	2E-03	3E-04	NA	NA	NA	NA	NA	2E-05	NA	3E-03
WWC - Reach C	Aluminum	NA	1E+00	NA	NA	5E-03	NA	NA	2E-02	3E-03	1E+00
	Antimony	NA	2E-01	NA	NA	2E-02	NA	NA	5E-04	1E-03	2E-01
	Arsenic	3E-02	3E+00	NA	NA	6E-03	NA	NA	5E-02	6E-02	3E+00
	Barium	NA	4E-02	NA	NA	5E-04	NA	NA	5E-04	3E-04	4E-02
	Beryllium	NA	NA	NA	NA	2E-06	NA	NA	NA	NA	2E-06
	Cadmium	NA	1E-03	NA	NA	5E-05	NA	NA	2E-05	2E-05	1E-03
	Chromium	NA	9E-06	NA	NA	7E-07	NA	NA	3E-07	1E-06	1E-05
	Copper	NA	5E-03	NA	NA	1E-04	NA	NA	1E-04	2E-04	5E-03
	Lead	NA	6E-02	NA	NA	1E-04	NA	NA	4E-04	2E-03	6E-02
	Manganese	NA	2E-02	NA	NA	9E-05	NA	NA	5E-04	1E-04	2E-02
	Mercury	NA	2E-04	NA	NA	8E-06	NA	NA	6E-06	1E-04	3E-04
	Molybdenum	NA	1E-01	NA	NA	NA	NA	NA	NA	NA	1E-01
	Thallium	NA	NA	NA	NA	7E-04	NA	NA	NA	NA	7E-04
	Vanadium	NA	2E-02	NA	NA	7E-05	NA	NA	3E-04	2E-04	2E-02
	Zinc	5E-05	2E-04	NA	NA	4E-05	NA	NA	2E-05	2E-04	4E-04
WWC - Reach D	Aluminum	NA	2E+00	NA	NA	2E-02	NA	NA	3E-02	2E-02	2E+00
	Antimony	NA	3E-02	NA	NA	2E-02	NA	NA	1E-03	1E-03	6E-02
	Arsenic	5E-02	2E+00	NA	NA	5E-03	NA	NA	4E-02	2E-02	2E+00
	Barium	NA	4E-02	NA	NA	5E-04	NA	NA	6E-04	7E-04	4E-02
	Beryllium	NA	NA	NA	NA	2E-06	NA	NA	NA	NA	2E-06
	Cadmium	NA	1E-03	NA	NA	6E-05	NA	NA	1E-05	6E-05	1E-03
	Chromium	NA	9E-06	NA	NA	8E-07	NA	NA	3E-07	1E-06	1E-05
	Copper	NA	2E-03	NA	NA	2E-04	NA	NA	1E-04	9E-05	2E-03
	Lead	NA	2E-02	NA	NA	1E-04	NA	NA	2E-04	8E-05	2E-02
	Manganese	NA	2E-02	NA	NA	7E-05	NA	NA	2E-03	2E-03	2E-02
	Mercury	NA	9E-05	NA	NA	7E-06	NA	NA	1E-05	9E-05	2E-04
	Molybdenum	NA	7E-02	NA	NA	NA	NA	NA	NA	NA	7E-02
	Thallium	NA	NA	NA	NA	5E-04	NA	NA	NA	NA	5E-04
	Vanadium	NA	3E-02	NA	NA	9E-05	NA	NA	4E-04	5E-04	3E-02
	Zinc	2E-04	1E-04	NA	NA	5E-05	NA	NA	2E-05	1E-04	5E-04

# APPENDIX L

## Mink

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART A: HQ VALUES CALCULATED USING NOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
BFR - Reach A	Aluminum	NA	1E+00	NA	NA	NA	NA	NA	NA	8E-02	1E+00
	Antimony	NA	3E-02	NA	NA	NA	NA	NA	NA	1E-03	3E-02
	Arsenic	2E-03	4E-02	NA	NA	NA	NA	NA	NA	4E-03	4E-02
	Barium	NA	5E-02	NA	NA	NA	NA	NA	NA	1E-03	5E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	2E-03	NA	NA	NA	NA	NA	NA	4E-05	2E-03
	Chromium	NA	5E-06	NA	NA	NA	NA	NA	NA	1E-06	6E-06
	Copper	NA	9E-04	NA	NA	NA	NA	NA	NA	1E-04	1E-03
	Lead	NA	2E-02	NA	NA	NA	NA	NA	NA	3E-04	2E-02
	Manganese	NA	1E-02	NA	NA	NA	NA	NA	NA	6E-04	1E-02
	Mercury	NA	1E-05	NA	NA	NA	NA	NA	NA	8E-05	1E-04
	Molybdenum	NA	2E-01	NA	NA	NA	NA	NA	NA	NA	2E-01
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	3E-02	NA	NA	NA	NA	NA	NA	1E-03	3E-02
	Zinc	4E-06	1E-04	NA	NA	NA	NA	NA	NA	1E-04	2E-04
BFR - Reach B	Aluminum	NA	1E+00	NA	NA	NA	NA	NA	1E-02	5E-02	1E+00
	Antimony	NA	4E-02	NA	NA	NA	NA	NA	9E-04	1E-03	4E-02
	Arsenic	8E-04	4E+00	NA	NA	NA	NA	NA	3E-03	1E-02	4E+00
	Barium	NA	4E-02	NA	NA	NA	NA	NA	3E-04	8E-04	4E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	1E-03	NA	NA	NA	NA	NA	9E-06	4E-05	1E-03
	Chromium	NA	6E-06	NA	NA	NA	NA	NA	3E-07	1E-06	7E-06
	Copper	NA	1E-03	NA	NA	NA	NA	NA	1E-04	1E-04	2E-03
	Lead	NA	3E-02	NA	NA	NA	NA	NA	1E-04	2E-04	3E-02
	Manganese	NA	2E-02	NA	NA	NA	NA	NA	2E-03	9E-04	2E-02
	Mercury	NA	5E-05	NA	NA	NA	NA	NA	NA	1E-04	2E-04
	Molybdenum	NA	8E-02	NA	NA	NA	NA	NA	NA	NA	8E-02
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	2E-02	NA	NA	NA	NA	NA	3E-04	8E-04	2E-02
	Zinc	4E-06	1E-04	NA	NA	NA	NA	NA	2E-05	2E-04	3E-04
SPC	Aluminum	NA	6E-01	NA	NA	9E-03	NA	NA	1E-02	9E-03	6E-01
	Antimony	NA	3E-02	NA	NA	2E-02	NA	NA	2E-04	1E-03	6E-02
	Arsenic	8E-04	4E-02	NA	NA	6E-04	NA	NA	1E-03	1E-03	4E-02
	Barium	NA	3E-02	NA	NA	8E-04	NA	NA	4E-04	5E-04	3E-02
	Beryllium	NA	NA	NA	NA	2E-06	NA	NA	NA	NA	2E-06
	Cadmium	NA	3E-04	NA	NA	5E-05	NA	NA	3E-06	2E-05	4E-04
	Chromium	NA	3E-06	NA	NA	7E-07	NA	NA	3E-07	4E-06	8E-06
	Copper	NA	3E-04	NA	NA	1E-04	NA	NA	5E-05	8E-05	6E-04
	Lead	NA	2E-02	NA	NA	1E-03	NA	NA	2E-04	1E-04	2E-02
	Manganese	NA	4E-03	NA	NA	1E-04	NA	NA	2E-04	1E-04	5E-03
	Mercury	NA	1E-05	NA	NA	2E-05	NA	NA	5E-06	8E-05	1E-04
	Molybdenum	NA	3E-03	NA	NA	NA	NA	NA	NA	NA	3E-03
	Thallium	NA	NA	NA	NA	7E-04	NA	NA	NA	NA	7E-04
	Vanadium	NA	6E-03	NA	NA	1E-04	NA	NA	2E-04	4E-04	7E-03
	Zinc	4E-06	3E-05	NA	NA	5E-05	NA	NA	2E-05	2E-04	3E-04

# APPENDIX L

## Mink

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART B: HQ VALUES CALCULATED USING LOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
WWC - Reach A	Aluminum	NA	3E-01	NA	NA	8E-03	NA	NA	8E-03	NA	3E-01
	Antimony	NA	7E-02	NA	NA	8E-03	NA	NA	1E-03	NA	8E-02
	Arsenic	1E-03	2E-01	NA	NA	3E-04	NA	NA	4E-02	NA	2E-01
	Barium	NA	1E-02	NA	NA	4E-04	NA	NA	9E-04	NA	1E-02
	Beryllium	NA	NA	NA	NA	7E-07	NA	NA	NA	NA	7E-07
	Cadmium	NA	4E-04	NA	NA	3E-05	NA	NA	3E-05	NA	5E-04
	Chromium	NA	3E-06	NA	NA	3E-07	NA	NA	1E-07	NA	4E-06
	Copper	NA	1E-03	NA	NA	7E-05	NA	NA	7E-05	NA	1E-03
	Lead	NA	1E-02	NA	NA	2E-04	NA	NA	1E-04	NA	1E-02
	Manganese	NA	8E-03	NA	NA	5E-05	NA	NA	4E-03	NA	1E-02
	Mercury	NA	2E-05	NA	NA	1E-07	NA	NA	NA	NA	2E-05
	Molybdenum	NA	3E-03	NA	NA	NA	NA	NA	NA	NA	3E-03
	Thallium	NA	NA	NA	NA	2E-04	NA	NA	NA	NA	2E-04
	Vanadium	NA	6E-03	NA	NA	4E-05	NA	NA	1E-04	NA	6E-03
	Zinc	3E-04	6E-05	NA	NA	1E-05	NA	NA	2E-05	NA	4E-04
WWC - Reach B	Aluminum	NA	3E-01	NA	NA	NA	NA	NA	4E-03	NA	3E-01
	Antimony	NA	3E-02	NA	NA	NA	NA	NA	9E-05	NA	3E-02
	Arsenic	2E-03	4E-01	NA	NA	NA	NA	NA	4E-03	NA	4E-01
	Barium	NA	3E-02	NA	NA	NA	NA	NA	1E-04	NA	3E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	7E-04	NA	NA	NA	NA	NA	4E-06	NA	7E-04
	Chromium	NA	5E-06	NA	NA	NA	NA	NA	1E-07	NA	5E-06
	Copper	NA	3E-03	NA	NA	NA	NA	NA	1E-04	NA	3E-03
	Lead	NA	2E-01	NA	NA	NA	NA	NA	9E-05	NA	2E-01
	Manganese	NA	8E-03	NA	NA	NA	NA	NA	2E-04	NA	8E-03
	Mercury	NA	3E-05	NA	NA	NA	NA	NA	NA	NA	3E-05
	Molybdenum	NA	6E-03	NA	NA	NA	NA	NA	NA	NA	6E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	9E-03	NA	NA	NA	NA	NA	7E-05	NA	9E-03
	Zinc	8E-04	9E-05	NA	NA	NA	NA	NA	7E-06	NA	9E-04
WWC - Reach C	Aluminum	NA	2E-01	NA	NA	1E-03	NA	NA	5E-03	6E-04	3E-01
	Antimony	NA	5E-02	NA	NA	8E-03	NA	NA	2E-04	4E-04	6E-02
	Arsenic	1E-02	1E+00	NA	NA	2E-03	NA	NA	2E-02	2E-02	1E+00
	Barium	NA	1E-02	NA	NA	2E-04	NA	NA	2E-04	9E-05	1E-02
	Beryllium	NA	NA	NA	NA	5E-07	NA	NA	NA	NA	5E-07
	Cadmium	NA	6E-04	NA	NA	2E-05	NA	NA	8E-06	8E-06	6E-04
	Chromium	NA	3E-06	NA	NA	2E-07	NA	NA	1E-07	3E-07	4E-06
	Copper	NA	3E-03	NA	NA	1E-04	NA	NA	1E-04	1E-04	4E-03
	Lead	NA	3E-02	NA	NA	5E-05	NA	NA	2E-04	1E-03	3E-02
	Manganese	NA	6E-03	NA	NA	3E-05	NA	NA	2E-04	4E-05	7E-03
	Mercury	NA	6E-05	NA	NA	3E-06	NA	NA	2E-06	3E-05	1E-04
	Molybdenum	NA	5E-03	NA	NA	NA	NA	NA	NA	NA	5E-03
	Thallium	NA	NA	NA	NA	2E-04	NA	NA	NA	NA	2E-04
	Vanadium	NA	6E-03	NA	NA	2E-05	NA	NA	1E-04	8E-05	7E-03
	Zinc	2E-05	6E-05	NA	NA	1E-05	NA	NA	8E-06	5E-05	1E-04
WWC - Reach D	Aluminum	NA	4E-01	NA	NA	3E-03	NA	NA	5E-03	3E-03	4E-01
	Antimony	NA	1E-02	NA	NA	8E-03	NA	NA	4E-04	4E-04	2E-02
	Arsenic	2E-02	7E-01	NA	NA	2E-03	NA	NA	1E-02	7E-03	8E-01
	Barium	NA	1E-02	NA	NA	2E-04	NA	NA	2E-04	2E-04	1E-02
	Beryllium	NA	NA	NA	NA	5E-07	NA	NA	NA	NA	5E-07
	Cadmium	NA	5E-04	NA	NA	3E-05	NA	NA	7E-06	3E-05	6E-04
	Chromium	NA	3E-06	NA	NA	3E-07	NA	NA	1E-07	3E-07	4E-06
	Copper	NA	1E-03	NA	NA	1E-04	NA	NA	9E-05	6E-05	1E-03
	Lead	NA	1E-02	NA	NA	7E-05	NA	NA	1E-04	4E-05	1E-02
	Manganese	NA	6E-03	NA	NA	2E-05	NA	NA	8E-04	7E-04	7E-03
	Mercury	NA	3E-05	NA	NA	2E-06	NA	NA	4E-06	3E-05	7E-05
	Molybdenum	NA	3E-03	NA	NA	NA	NA	NA	NA	NA	3E-03
	Thallium	NA	NA	NA	NA	2E-04	NA	NA	NA	NA	2E-04
	Vanadium	NA	1E-02	NA	NA	3E-05	NA	NA	1E-04	2E-04	1E-02
	Zinc	6E-05	4E-05	NA	NA	2E-05	NA	NA	6E-06	4E-05	2E-04

# APPENDIX L

## Mink

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART B: HQ VALUES CALCULATED USING LOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
BFR - Reach A	Aluminum	NA	2E-01	NA	NA	NA	NA	NA	NA	2E-02	2E-01
	Antimony	NA	1E-02	NA	NA	NA	NA	NA	NA	5E-04	1E-02
	Arsenic	8E-04	1E-02	NA	NA	NA	NA	NA	NA	1E-03	1E-02
	Barium	NA	2E-02	NA	NA	NA	NA	NA	NA	5E-04	2E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	8E-04	NA	NA	NA	NA	NA	NA	2E-05	8E-04
	Chromium	NA	2E-06	NA	NA	NA	NA	NA	NA	4E-07	2E-06
	Copper	NA	6E-04	NA	NA	NA	NA	NA	NA	7E-05	7E-04
	Lead	NA	8E-03	NA	NA	NA	NA	NA	NA	2E-04	8E-03
	Manganese	NA	4E-03	NA	NA	NA	NA	NA	NA	2E-04	5E-03
	Mercury	NA	4E-06	NA	NA	NA	NA	NA	NA	3E-05	3E-05
	Molybdenum	NA	7E-03	NA	NA	NA	NA	NA	NA	NA	7E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	9E-03	NA	NA	NA	NA	NA	NA	4E-04	1E-02
	Zinc	1E-06	3E-05	NA	NA	NA	NA	NA	NA	5E-05	8E-05
BFR - Reach B	Aluminum	NA	3E-01	NA	NA	NA	NA	NA	3E-03	1E-02	3E-01
	Antimony	NA	1E-02	NA	NA	NA	NA	NA	3E-04	5E-04	1E-02
	Arsenic	3E-04	1E+00	NA	NA	NA	NA	NA	9E-04	4E-03	1E+00
	Barium	NA	1E-02	NA	NA	NA	NA	NA	1E-04	3E-04	1E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	5E-04	NA	NA	NA	NA	NA	4E-06	2E-05	5E-04
	Chromium	NA	2E-06	NA	NA	NA	NA	NA	9E-08	4E-07	2E-06
	Copper	NA	1E-03	NA	NA	NA	NA	NA	7E-05	8E-05	1E-03
	Lead	NA	1E-02	NA	NA	NA	NA	NA	7E-05	9E-05	1E-02
	Manganese	NA	6E-03	NA	NA	NA	NA	NA	7E-04	3E-04	7E-03
	Mercury	NA	2E-05	NA	NA	NA	NA	NA	NA	4E-05	6E-05
	Molybdenum	NA	3E-03	NA	NA	NA	NA	NA	NA	NA	3E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	8E-03	NA	NA	NA	NA	NA	9E-05	3E-04	8E-03
	Zinc	1E-06	3E-05	NA	NA	NA	NA	NA	5E-06	8E-05	1E-04
SPC	Aluminum	NA	1E-01	NA	NA	2E-03	NA	NA	2E-03	2E-03	1E-01
	Antimony	NA	1E-02	NA	NA	8E-03	NA	NA	8E-05	5E-04	2E-02
	Arsenic	3E-04	1E-02	NA	NA	2E-04	NA	NA	3E-04	5E-04	1E-02
	Barium	NA	9E-03	NA	NA	3E-04	NA	NA	1E-04	2E-04	9E-03
	Beryllium	NA	NA	NA	NA	5E-07	NA	NA	NA	NA	5E-07
	Cadmium	NA	1E-04	NA	NA	2E-05	NA	NA	1E-06	9E-06	2E-04
	Chromium	NA	1E-06	NA	NA	2E-07	NA	NA	9E-08	1E-06	3E-06
	Copper	NA	2E-04	NA	NA	9E-05	NA	NA	4E-05	5E-05	4E-04
	Lead	NA	9E-03	NA	NA	6E-04	NA	NA	1E-04	7E-05	1E-02
	Manganese	NA	1E-03	NA	NA	3E-05	NA	NA	6E-05	3E-05	1E-03
	Mercury	NA	4E-06	NA	NA	7E-06	NA	NA	2E-06	3E-05	4E-05
	Molybdenum	NA	1E-04	NA	NA	NA	NA	NA	NA	NA	1E-04
	Thallium	NA	NA	NA	NA	2E-04	NA	NA	NA	NA	2E-04
	Vanadium	NA	2E-03	NA	NA	4E-05	NA	NA	6E-05	1E-04	2E-03
	Zinc	1E-06	1E-05	NA	NA	2E-05	NA	NA	6E-06	5E-05	9E-05

# APPENDIX L

## Meadow Vole

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART A: HQ VALUES CALCULATED USING NOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
WWC - Reach A	Aluminum	NA	NA	6E+01	1E-01	NA	9E-04	1E-03	NA	NA	6E+01
	Antimony	NA	NA	7E+00	5E-02	NA	1E-02	2E-02	NA	NA	7E+00
	Arsenic	3E-03	NA	2E-02	1E-02	NA	4E-05	1E-01	NA	NA	1E-01
	Barium	NA	NA	1E+00	3E-02	NA	8E-05	4E-04	NA	NA	1E+00
	Beryllium	NA	NA	2E-02	1E-04	NA	8E-07	5E-06	NA	NA	2E-02
	Cadmium	NA	NA	1E-02	1E-03	NA	1E-05	1E-04	NA	NA	1E-02
	Chromium	NA	NA	2E-04	1E-06	NA	2E-07	1E-07	NA	NA	2E-04
	Copper	NA	NA	3E-03	1E-04	NA	3E-05	1E-05	NA	NA	3E-03
	Lead	NA	NA	2E+00	9E-03	NA	6E-05	3E-04	NA	NA	2E+00
	Manganese	NA	NA	4E-01	5E-02	NA	2E-04	9E-05	NA	NA	4E-01
	Mercury	NA	NA	3E-03	4E-05	NA	2E-07	1E-05	NA	NA	3E-03
	Molybdenum	NA	NA	5E-01	NA	NA	NA	NA	NA	NA	5E-01
	Thallium	NA	NA	2E+00	2E-01	NA	3E-04	8E-02	NA	NA	2E+00
	Vanadium	NA	NA	2E-01	1E-03	NA	2E-05	1E-04	NA	NA	2E-01
	Zinc	9E-03	NA	1E-02	1E-03	NA	2E-04	1E-04	NA	NA	2E-02
WWC - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	5E-03	NA	NA	NA	NA	NA	NA	NA	NA	5E-03
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	2E-02	NA	NA	NA	NA	NA	NA	NA	NA	2E-02
WWC - Reach C	Aluminum	NA	NA	6E+01	4E-02	NA	2E-03	2E-03	NA	NA	6E+01
	Antimony	NA	NA	2E+01	4E-02	NA	1E-02	3E-03	NA	NA	2E+01
	Arsenic	3E-02	NA	4E+02	1E-01	NA	2E-03	2E-01	NA	NA	4E+02
	Barium	NA	NA	7E-01	6E-03	NA	3E-05	1E-04	NA	NA	7E-01
	Beryllium	NA	NA	3E-03	7E-05	NA	8E-07	5E-06	NA	NA	3E-03
	Cadmium	NA	NA	2E-02	1E-03	NA	4E-05	2E-04	NA	NA	2E-02
	Chromium	NA	NA	3E-04	1E-06	NA	9E-07	2E-07	NA	NA	3E-04
	Copper	NA	NA	2E-02	1E-04	NA	4E-05	1E-05	NA	NA	2E-02
	Lead	NA	NA	3E+00	2E-03	NA	2E-05	1E-04	NA	NA	3E+00
	Manganese	NA	NA	1E+00	8E-03	NA	4E-05	8E-05	NA	NA	1E+00
	Mercury	NA	NA	5E-03	2E-05	NA	2E-07	3E-06	NA	NA	5E-03
	Molybdenum	NA	NA	4E+00	NA	NA	NA	NA	NA	NA	4E+00
	Thallium	NA	NA	8E+00	1E-01	NA	3E-04	8E-03	NA	NA	9E+00
	Vanadium	NA	NA	4E-01	1E-03	NA	7E-06	4E-05	NA	NA	4E-01
	Zinc	6E-04	NA	3E-02	1E-03	NA	2E-04	1E-04	NA	NA	3E-02
WWC - Reach D	Aluminum	NA	NA	6E+01	3E-02	NA	7E-04	7E-03	NA	NA	6E+01
	Antimony	NA	NA	2E+01	3E-02	NA	1E-02	3E-03	NA	NA	2E+01
	Arsenic	4E-02	NA	3E+02	5E-02	NA	7E-03	2E-01	NA	NA	3E+02
	Barium	NA	NA	6E-01	1E-02	NA	3E-05	1E-04	NA	NA	6E-01
	Beryllium	NA	NA	3E-03	5E-05	NA	8E-07	5E-06	NA	NA	3E-03
	Cadmium	NA	NA	3E-02	5E-04	NA	3E-05	3E-04	NA	NA	3E-02
	Chromium	NA	NA	2E-04	2E-06	NA	3E-07	2E-07	NA	NA	2E-04
	Copper	NA	NA	1E-02	1E-04	NA	3E-05	1E-05	NA	NA	1E-02
	Lead	NA	NA	2E+00	1E-03	NA	2E-05	3E-04	NA	NA	2E+00
	Manganese	NA	NA	1E+00	3E-02	NA	4E-05	2E-04	NA	NA	1E+00
	Mercury	NA	NA	3E-03	1E-05	NA	2E-07	4E-06	NA	NA	3E-03
	Molybdenum	NA	NA	2E+00	NA	NA	NA	NA	NA	NA	2E+00
	Thallium	NA	NA	8E+00	9E-02	NA	3E-04	9E-03	NA	NA	8E+00
	Vanadium	NA	NA	3E-01	8E-04	NA	2E-05	7E-05	NA	NA	3E-01
	Zinc	2E-03	NA	2E-02	9E-04	NA	2E-04	1E-04	NA	NA	3E-02

# APPENDIX L

## Meadow Vole

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART A: HQ VALUES CALCULATED USING NOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
BFR - Reach A	Aluminum	NA	NA	5E+01	NA	NA	NA	NA	NA	NA	5E+01
	Antimony	NA	NA	8E-01	NA	NA	NA	NA	NA	NA	8E-01
	Arsenic	2E-03	NA	1E+00	NA	NA	NA	NA	NA	NA	1E+00
	Barium	NA	NA	6E-01	NA	NA	NA	NA	NA	NA	6E-01
	Beryllium	NA	NA	4E-03	NA	NA	NA	NA	NA	NA	4E-03
	Cadmium	NA	NA	2E-02	NA	NA	NA	NA	NA	NA	2E-02
	Chromium	NA	NA	2E-04	NA	NA	NA	NA	NA	NA	2E-04
	Copper	NA	NA	6E-03	NA	NA	NA	NA	NA	NA	6E-03
	Lead	NA	NA	1E+00	NA	NA	NA	NA	NA	NA	1E+00
	Manganese	NA	NA	5E-01	NA	NA	NA	NA	NA	NA	5E-01
	Mercury	NA	NA	9E-05	NA	NA	NA	NA	NA	NA	9E-05
	Molybdenum	NA	NA	4E+00	NA	NA	NA	NA	NA	NA	4E+00
	Thallium	NA	NA	3E+00	NA	NA	NA	NA	NA	NA	3E+00
	Vanadium	NA	NA	4E-01	NA	NA	NA	NA	NA	NA	4E-01
	Zinc	4E-05	NA	3E-02	NA	NA	NA	NA	NA	NA	3E-02
BFR - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	7E-04	NA	NA	NA	NA	NA	NA	NA	NA	7E-04
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	4E-05	NA	NA	NA	NA	NA	NA	NA	NA	4E-05
SPC	Aluminum	NA	NA	2E+01	6E-02	NA	4E-04	NA	NA	NA	2E+01
	Antimony	NA	NA	1E+01	3E-02	NA	1E-02	NA	NA	NA	1E+01
	Arsenic	7E-04	NA	3E+00	8E-03	NA	1E-04	NA	NA	NA	3E+00
	Barium	NA	NA	4E-01	1E-02	NA	3E-05	NA	NA	NA	5E-01
	Beryllium	NA	NA	2E-03	6E-05	NA	8E-07	NA	NA	NA	3E-03
	Cadmium	NA	NA	3E-02	6E-04	NA	3E-05	NA	NA	NA	3E-02
	Chromium	NA	NA	1E-04	1E-06	NA	7E-08	NA	NA	NA	1E-04
	Copper	NA	NA	2E-03	1E-04	NA	2E-05	NA	NA	NA	2E-03
	Lead	NA	NA	2E+00	1E-02	NA	1E-05	NA	NA	NA	2E+00
	Manganese	NA	NA	2E-01	4E-03	NA	2E-05	NA	NA	NA	2E-01
	Mercury	NA	NA	6E-03	1E-05	NA	2E-07	NA	NA	NA	6E-03
	Molybdenum	NA	NA	9E-01	NA	NA	NA	NA	NA	NA	9E-01
	Thallium	NA	NA	3E+00	1E-01	NA	3E-04	NA	NA	NA	3E+00
	Vanadium	NA	NA	2E-01	9E-04	NA	7E-06	NA	NA	NA	2E-01
	Zinc	4E-05	NA	1E-02	9E-04	NA	2E-04	NA	NA	NA	1E-02

# APPENDIX L

## Meadow Vole

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART B: HQ VALUES CALCULATED USING LOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
WWC - Reach A	Aluminum	NA	NA	1E+01	3E-02	NA	2E-04	2E-04	NA	NA	1E+01
	Antimony	NA	NA	2E+00	2E-02	NA	4E-03	5E-03	NA	NA	2E+00
	Arsenic	1E-03	NA	8E-03	3E-03	NA	1E-05	3E-02	NA	NA	5E-02
	Barium	NA	NA	4E-01	9E-03	NA	3E-05	1E-04	NA	NA	4E-01
	Beryllium	NA	NA	6E-03	3E-05	NA	3E-07	2E-06	NA	NA	6E-03
	Cadmium	NA	NA	5E-03	5E-04	NA	5E-06	7E-05	NA	NA	6E-03
	Chromium	NA	NA	7E-05	3E-07	NA	7E-08	4E-08	NA	NA	7E-05
	Copper	NA	NA	1E-03	6E-05	NA	1E-05	5E-06	NA	NA	2E-03
	Lead	NA	NA	6E-01	3E-03	NA	2E-05	9E-05	NA	NA	6E-01
	Manganese	NA	NA	1E-01	1E-02	NA	6E-05	3E-05	NA	NA	1E-01
	Mercury	NA	NA	1E-03	1E-05	NA	6E-08	3E-06	NA	NA	1E-03
	Molybdenum	NA	NA	2E-02	NA	NA	NA	NA	NA	NA	2E-02
	Thallium	NA	NA	6E-01	5E-02	NA	9E-05	3E-02	NA	NA	6E-01
	Vanadium	NA	NA	7E-02	5E-04	NA	8E-06	5E-05	NA	NA	7E-02
	Zinc	4E-03	NA	7E-03	5E-04	NA	1E-04	7E-05	NA	NA	1E-02

WWC - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	2E-03	NA	NA	NA	NA	NA	NA	NA	NA	2E-03
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	1E-02	NA	NA	NA	NA	NA	NA	NA	NA	1E-02

WWC - Reach C	Aluminum	NA	NA	1E+01	8E-03	NA	4E-04	4E-04	NA	NA	1E+01
	Antimony	NA	NA	6E+00	1E-02	NA	4E-03	8E-04	NA	NA	6E+00
	Arsenic	9E-03	NA	1E+02	5E-02	NA	6E-04	5E-02	NA	NA	1E+02
	Barium	NA	NA	2E-01	2E-03	NA	9E-06	3E-05	NA	NA	2E-01
	Beryllium	NA	NA	1E-03	2E-05	NA	3E-07	2E-06	NA	NA	1E-03
	Cadmium	NA	NA	1E-02	5E-04	NA	2E-05	1E-04	NA	NA	1E-02
	Chromium	NA	NA	9E-05	3E-07	NA	3E-07	6E-08	NA	NA	9E-05
	Copper	NA	NA	9E-03	7E-05	NA	2E-05	6E-06	NA	NA	9E-03
	Lead	NA	NA	1E+00	8E-04	NA	6E-06	4E-05	NA	NA	1E+00
	Manganese	NA	NA	3E-01	3E-03	NA	1E-05	3E-05	NA	NA	3E-01
	Mercury	NA	NA	2E-03	6E-06	NA	5E-08	1E-06	NA	NA	2E-03
	Molybdenum	NA	NA	2E-01	NA	NA	NA	NA	NA	NA	2E-01
	Thallium	NA	NA	3E+00	4E-02	NA	9E-05	3E-03	NA	NA	3E+00
	Vanadium	NA	NA	1E-01	3E-04	NA	2E-06	1E-05	NA	NA	1E-01
	Zinc	3E-04	NA	2E-02	5E-04	NA	9E-05	7E-05	NA	NA	2E-02

WWC - Reach D	Aluminum	NA	NA	1E+01	7E-03	NA	2E-04	2E-03	NA	NA	1E+01
	Antimony	NA	NA	7E+00	1E-02	NA	4E-03	9E-04	NA	NA	7E+00
	Arsenic	1E-02	NA	1E+02	2E-02	NA	2E-03	7E-02	NA	NA	1E+02
	Barium	NA	NA	2E-01	5E-03	NA	1E-05	4E-05	NA	NA	2E-01
	Beryllium	NA	NA	1E-03	2E-05	NA	3E-07	2E-06	NA	NA	1E-03
	Cadmium	NA	NA	1E-02	3E-04	NA	1E-05	1E-04	NA	NA	1E-02
	Chromium	NA	NA	8E-05	7E-07	NA	9E-08	7E-08	NA	NA	8E-05
	Copper	NA	NA	6E-03	5E-05	NA	1E-05	5E-06	NA	NA	6E-03
	Lead	NA	NA	6E-01	4E-04	NA	5E-06	1E-04	NA	NA	6E-01
	Manganese	NA	NA	3E-01	1E-02	NA	1E-05	8E-05	NA	NA	4E-01
	Mercury	NA	NA	1E-03	4E-06	NA	5E-08	1E-06	NA	NA	1E-03
	Molybdenum	NA	NA	9E-02	NA	NA	NA	NA	NA	NA	9E-02
	Thallium	NA	NA	3E+00	3E-02	NA	9E-05	3E-03	NA	NA	3E+00
	Vanadium	NA	NA	1E-01	3E-04	NA	8E-06	2E-05	NA	NA	1E-01
	Zinc	9E-04	NA	1E-02	5E-04	NA	1E-04	7E-05	NA	NA	1E-02

# APPENDIX L

## Meadow Vole

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART B: HQ VALUES CALCULATED USING LOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
BFR - Reach A	Aluminum	NA	NA	1E+01	NA	NA	NA	NA	NA	NA	1E+01
	Antimony	NA	NA	3E-01	NA	NA	NA	NA	NA	NA	3E-01
	Arsenic	7E-04	NA	5E-01	NA	NA	NA	NA	NA	NA	5E-01
	Barium	NA	NA	2E-01	NA	NA	NA	NA	NA	NA	2E-01
	Beryllium	NA	NA	1E-03	NA	NA	NA	NA	NA	NA	1E-03
	Cadmium	NA	NA	1E-02	NA	NA	NA	NA	NA	NA	1E-02
	Chromium	NA	NA	6E-05	NA	NA	NA	NA	NA	NA	6E-05
	Copper	NA	NA	3E-03	NA	NA	NA	NA	NA	NA	3E-03
	Lead	NA	NA	5E-01	NA	NA	NA	NA	NA	NA	5E-01
	Manganese	NA	NA	1E-01	NA	NA	NA	NA	NA	NA	1E-01
	Mercury	NA	NA	3E-05	NA	NA	NA	NA	NA	NA	3E-05
	Molybdenum	NA	NA	2E-01	NA	NA	NA	NA	NA	NA	2E-01
	Thallium	NA	NA	9E-01	NA	NA	NA	NA	NA	NA	9E-01
	Vanadium	NA	NA	1E-01	NA	NA	NA	NA	NA	NA	1E-01
	Zinc	2E-05	NA	1E-02	NA	NA	NA	NA	NA	NA	1E-02

BFR - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	2E-04	NA	NA	NA	NA	NA	NA	NA	NA	2E-04
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	2E-05	NA	NA	NA	NA	NA	NA	NA	NA	2E-05

SPC	Aluminum	NA	NA	4E+00	1E-02	NA	8E-05	NA	NA	NA	4E+00
	Antimony	NA	NA	5E+00	1E-02	NA	4E-03	NA	NA	NA	5E+00
	Arsenic	2E-04	NA	1E+00	3E-03	NA	4E-05	NA	NA	NA	1E+00
	Barium	NA	NA	1E-01	5E-03	NA	1E-05	NA	NA	NA	2E-01
	Beryllium	NA	NA	8E-04	2E-05	NA	3E-07	NA	NA	NA	8E-04
	Cadmium	NA	NA	2E-02	3E-04	NA	1E-05	NA	NA	NA	2E-02
	Chromium	NA	NA	4E-05	4E-07	NA	2E-08	NA	NA	NA	4E-05
	Copper	NA	NA	9E-04	6E-05	NA	1E-05	NA	NA	NA	1E-03
	Lead	NA	NA	8E-01	3E-03	NA	4E-06	NA	NA	NA	8E-01
	Manganese	NA	NA	7E-02	1E-03	NA	6E-06	NA	NA	NA	7E-02
	Mercury	NA	NA	2E-03	5E-06	NA	5E-08	NA	NA	NA	2E-03
	Molybdenum	NA	NA	4E-02	NA	NA	NA	NA	NA	NA	4E-02
	Thallium	NA	NA	1E+00	4E-02	NA	9E-05	NA	NA	NA	1E+00
	Vanadium	NA	NA	5E-02	3E-04	NA	2E-06	NA	NA	NA	5E-02
	Zinc	2E-05	NA	6E-03	5E-04	NA	8E-05	NA	NA	NA	6E-03

# APPENDIX L

## Masked Shrew

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART A: HQ VALUES CALCULATED USING NOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
WWC - Reach A	Aluminum	NA	NA	3E+02	NA	NA	5E-02	6E-02	NA	NA	3E+02
	Antimony	NA	NA	4E+01	NA	NA	7E-01	9E-01	NA	NA	4E+01
	Arsenic	6E-03	NA	1E-01	NA	NA	2E-03	5E+00	NA	NA	6E+00
	Barium	NA	NA	1E+01	NA	NA	7E-03	4E-02	NA	NA	1E+01
	Beryllium	NA	NA	1E-01	NA	NA	4E-05	3E-04	NA	NA	1E-01
	Cadmium	NA	NA	1E-01	NA	NA	9E-04	1E-02	NA	NA	1E-01
	Chromium	NA	NA	1E-03	NA	NA	1E-05	7E-06	NA	NA	1E-03
	Copper	NA	NA	3E-02	NA	NA	3E-03	1E-03	NA	NA	3E-02
	Lead	NA	NA	2E+01	NA	NA	6E-03	2E-02	NA	NA	2E+01
	Manganese	NA	NA	2E+00	NA	NA	1E-02	5E-03	NA	NA	2E+00
	Mercury	NA	NA	3E-02	NA	NA	2E-05	9E-04	NA	NA	3E-02
	Molybdenum	NA	NA	3E+00	NA	NA	NA	NA	NA	NA	3E+00
	Thallium	NA	NA	9E+00	NA	NA	2E-02	5E+00	NA	NA	1E+01
	Vanadium	NA	NA	2E+00	NA	NA	2E-03	1E-02	NA	NA	2E+00
	Zinc	2E-02	NA	1E-01	NA	NA	2E-02	1E-02	NA	NA	2E-01
WWC - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	1E-02	NA	NA	NA	NA	NA	NA	NA	NA	1E-02
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	5E-02	NA	NA	NA	NA	NA	NA	NA	NA	5E-02
WWC - Reach C	Aluminum	NA	NA	3E+02	NA	NA	1E-01	1E-01	NA	NA	3E+02
	Antimony	NA	NA	1E+02	NA	NA	7E-01	1E-01	NA	NA	1E+02
	Arsenic	5E-02	NA	2E+03	NA	NA	9E-02	9E+00	NA	NA	2E+03
	Barium	NA	NA	7E+00	NA	NA	3E-03	9E-03	NA	NA	7E+00
	Beryllium	NA	NA	2E-02	NA	NA	4E-05	3E-04	NA	NA	2E-02
	Cadmium	NA	NA	2E-01	NA	NA	4E-03	2E-02	NA	NA	2E-01
	Chromium	NA	NA	1E-03	NA	NA	5E-05	1E-05	NA	NA	2E-03
	Copper	NA	NA	2E-01	NA	NA	3E-03	1E-03	NA	NA	2E-01
	Lead	NA	NA	3E+01	NA	NA	2E-03	1E-02	NA	NA	3E+01
	Manganese	NA	NA	6E+00	NA	NA	2E-03	5E-03	NA	NA	6E+00
	Mercury	NA	NA	5E-02	NA	NA	2E-05	3E-04	NA	NA	5E-02
	Molybdenum	NA	NA	2E+01	NA	NA	NA	NA	NA	NA	2E+01
	Thallium	NA	NA	5E+01	NA	NA	2E-02	5E-01	NA	NA	5E+01
	Vanadium	NA	NA	4E+00	NA	NA	7E-04	4E-03	NA	NA	4E+00
	Zinc	1E-03	NA	3E-01	NA	NA	2E-02	1E-02	NA	NA	3E-01
WWC - Reach D	Aluminum	NA	NA	3E+02	NA	NA	4E-02	4E-01	NA	NA	3E+02
	Antimony	NA	NA	1E+02	NA	NA	7E-01	2E-01	NA	NA	1E+02
	Arsenic	8E-02	NA	2E+03	NA	NA	4E-01	1E+01	NA	NA	2E+03
	Barium	NA	NA	6E+00	NA	NA	3E-03	1E-02	NA	NA	6E+00
	Beryllium	NA	NA	2E-02	NA	NA	4E-05	3E-04	NA	NA	2E-02
	Cadmium	NA	NA	3E-01	NA	NA	2E-03	2E-02	NA	NA	3E-01
	Chromium	NA	NA	1E-03	NA	NA	1E-05	1E-05	NA	NA	1E-03
	Copper	NA	NA	1E-01	NA	NA	3E-03	1E-03	NA	NA	1E-01
	Lead	NA	NA	2E+01	NA	NA	1E-03	3E-02	NA	NA	2E+01
	Manganese	NA	NA	6E+00	NA	NA	2E-03	1E-02	NA	NA	6E+00
	Mercury	NA	NA	3E-02	NA	NA	1E-05	4E-04	NA	NA	3E-02
	Molybdenum	NA	NA	1E+01	NA	NA	NA	NA	NA	NA	1E+01
	Thallium	NA	NA	4E+01	NA	NA	2E-02	5E-01	NA	NA	4E+01
	Vanadium	NA	NA	3E+00	NA	NA	2E-03	7E-03	NA	NA	3E+00
	Zinc	4E-03	NA	2E-01	NA	NA	2E-02	1E-02	NA	NA	2E-01

# APPENDIX L

## Masked Shrew

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART A: HQ VALUES CALCULATED USING NOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
BFR - Reach A	Aluminum	NA	NA	3E+02	NA	NA	NA	NA	NA	NA	3E+02
	Antimony	NA	NA	5E+00	NA	NA	NA	NA	NA	NA	5E+00
	Arsenic	4E-03	NA	8E+00	NA	NA	NA	NA	NA	NA	8E+00
	Barium	NA	NA	6E+00	NA	NA	NA	NA	NA	NA	6E+00
	Beryllium	NA	NA	2E-02	NA	NA	NA	NA	NA	NA	2E-02
	Cadmium	NA	NA	2E-01	NA	NA	NA	NA	NA	NA	2E-01
	Chromium	NA	NA	1E-03	NA	NA	NA	NA	NA	NA	1E-03
	Copper	NA	NA	5E-02	NA	NA	NA	NA	NA	NA	5E-02
	Lead	NA	NA	1E+01	NA	NA	NA	NA	NA	NA	1E+01
	Manganese	NA	NA	3E+00	NA	NA	NA	NA	NA	NA	3E+00
	Mercury	NA	NA	8E-04	NA	NA	NA	NA	NA	NA	8E-04
	Molybdenum	NA	NA	2E+01	NA	NA	NA	NA	NA	NA	2E+01
	Thallium	NA	NA	1E+01	NA	NA	NA	NA	NA	NA	1E+01
	Vanadium	NA	NA	4E+00	NA	NA	NA	NA	NA	NA	4E+00
	Zinc	8E-05	NA	3E-01	NA	NA	NA	NA	NA	NA	3E-01
BFR - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	1E-03	NA	NA	NA	NA	NA	NA	NA	NA	1E-03
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	8E-05	NA	NA	NA	NA	NA	NA	NA	NA	8E-05
SPC	Aluminum	NA	NA	1E+02	NA	NA	2E-02	NA	NA	NA	1E+02
	Antimony	NA	NA	8E+01	NA	NA	7E-01	NA	NA	NA	8E+01
	Arsenic	1E-03	NA	2E+01	NA	NA	7E-03	NA	NA	NA	2E+01
	Barium	NA	NA	4E+00	NA	NA	3E-03	NA	NA	NA	4E+00
	Beryllium	NA	NA	1E-02	NA	NA	4E-05	NA	NA	NA	1E-02
	Cadmium	NA	NA	3E-01	NA	NA	2E-03	NA	NA	NA	3E-01
	Chromium	NA	NA	6E-04	NA	NA	4E-06	NA	NA	NA	6E-04
	Copper	NA	NA	2E-02	NA	NA	2E-03	NA	NA	NA	2E-02
	Lead	NA	NA	2E+01	NA	NA	1E-03	NA	NA	NA	2E+01
	Manganese	NA	NA	1E+00	NA	NA	1E-03	NA	NA	NA	1E+00
	Mercury	NA	NA	5E-02	NA	NA	1E-05	NA	NA	NA	5E-02
	Molybdenum	NA	NA	5E+00	NA	NA	NA	NA	NA	NA	5E+00
	Thallium	NA	NA	2E+01	NA	NA	2E-02	NA	NA	NA	2E+01
	Vanadium	NA	NA	2E+00	NA	NA	7E-04	NA	NA	NA	2E+00
	Zinc	8E-05	NA	1E-01	NA	NA	2E-02	NA	NA	NA	1E-01

# APPENDIX L

## Masked Shrew

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART B: HQ VALUES CALCULATED USING LOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
WWC - Reach A	Aluminum	NA	NA	7E+01	NA	NA	1E-02	1E-02	NA	NA	7E+01
	Antimony	NA	NA	1E+01	NA	NA	2E-01	3E-01	NA	NA	1E+01
	Arsenic	2E-03	NA	5E-02	NA	NA	8E-04	2E+00	NA	NA	2E+00
	Barium	NA	NA	4E+00	NA	NA	2E-03	1E-02	NA	NA	4E+00
	Beryllium	NA	NA	4E-02	NA	NA	1E-05	9E-05	NA	NA	4E-02
	Cadmium	NA	NA	5E-02	NA	NA	4E-04	7E-03	NA	NA	6E-02
	Chromium	NA	NA	4E-04	NA	NA	4E-06	2E-06	NA	NA	4E-04
	Copper	NA	NA	1E-02	NA	NA	1E-03	5E-04	NA	NA	2E-02
	Lead	NA	NA	6E+00	NA	NA	2E-03	8E-03	NA	NA	6E+00
	Manganese	NA	NA	6E-01	NA	NA	3E-03	2E-03	NA	NA	6E-01
	Mercury	NA	NA	9E-03	NA	NA	6E-06	3E-04	NA	NA	9E-03
	Molybdenum	NA	NA	1E-01	NA	NA	NA	NA	NA	NA	1E-01
	Thallium	NA	NA	3E+00	NA	NA	5E-03	2E+00	NA	NA	5E+00
	Vanadium	NA	NA	6E-01	NA	NA	7E-04	5E-03	NA	NA	6E-01
	Zinc	9E-03	NA	7E-02	NA	NA	1E-02	6E-03	NA	NA	9E-02
WWC - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	4E-03	NA	NA	NA	NA	NA	NA	NA	NA	4E-03
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	2E-02	NA	NA	NA	NA	NA	NA	NA	NA	2E-02
WWC - Reach C	Aluminum	NA	NA	7E+01	NA	NA	2E-02	2E-02	NA	NA	7E+01
	Antimony	NA	NA	3E+01	NA	NA	2E-01	5E-02	NA	NA	3E+01
	Arsenic	2E-02	NA	8E+02	NA	NA	3E-02	3E+00	NA	NA	8E+02
	Barium	NA	NA	2E+00	NA	NA	9E-04	3E-03	NA	NA	2E+00
	Beryllium	NA	NA	6E-03	NA	NA	1E-05	9E-05	NA	NA	6E-03
	Cadmium	NA	NA	9E-02	NA	NA	2E-03	1E-02	NA	NA	1E-01
	Chromium	NA	NA	5E-04	NA	NA	2E-05	3E-06	NA	NA	5E-04
	Copper	NA	NA	8E-02	NA	NA	2E-03	5E-04	NA	NA	8E-02
	Lead	NA	NA	1E+01	NA	NA	6E-04	4E-03	NA	NA	1E+01
	Manganese	NA	NA	2E+00	NA	NA	7E-04	1E-03	NA	NA	2E+00
	Mercury	NA	NA	2E-02	NA	NA	5E-06	1E-04	NA	NA	2E-02
	Molybdenum	NA	NA	9E-01	NA	NA	NA	NA	NA	NA	9E-01
	Thallium	NA	NA	2E+01	NA	NA	5E-03	2E-01	NA	NA	2E+01
	Vanadium	NA	NA	1E+00	NA	NA	2E-04	1E-03	NA	NA	1E+00
	Zinc	6E-04	NA	1E-01	NA	NA	8E-03	6E-03	NA	NA	2E-01
WWC - Reach D	Aluminum	NA	NA	7E+01	NA	NA	9E-03	9E-02	NA	NA	7E+01
	Antimony	NA	NA	4E+01	NA	NA	2E-01	5E-02	NA	NA	4E+01
	Arsenic	3E-02	NA	6E+02	NA	NA	1E-01	4E+00	NA	NA	6E+02
	Barium	NA	NA	2E+00	NA	NA	9E-04	4E-03	NA	NA	2E+00
	Beryllium	NA	NA	6E-03	NA	NA	1E-05	9E-05	NA	NA	6E-03
	Cadmium	NA	NA	1E-01	NA	NA	1E-03	1E-02	NA	NA	1E-01
	Chromium	NA	NA	4E-04	NA	NA	5E-06	4E-06	NA	NA	5E-04
	Copper	NA	NA	5E-02	NA	NA	1E-03	5E-04	NA	NA	6E-02
	Lead	NA	NA	6E+00	NA	NA	5E-04	9E-03	NA	NA	6E+00
	Manganese	NA	NA	2E+00	NA	NA	8E-04	4E-03	NA	NA	2E+00
	Mercury	NA	NA	9E-03	NA	NA	5E-06	1E-04	NA	NA	9E-03
	Molybdenum	NA	NA	5E-01	NA	NA	NA	NA	NA	NA	5E-01
	Thallium	NA	NA	1E+01	NA	NA	5E-03	2E-01	NA	NA	1E+01
	Vanadium	NA	NA	1E+00	NA	NA	7E-04	2E-03	NA	NA	1E+00
	Zinc	2E-03	NA	1E-01	NA	NA	9E-03	7E-03	NA	NA	1E-01

# APPENDIX L

## Masked Shrew

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART B: HQ VALUES CALCULATED USING LOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
BFR - Reach A	Aluminum	NA	NA	6E+01	NA	NA	NA	NA	NA	NA	6E+01
	Antimony	NA	NA	2E+00	NA	NA	NA	NA	NA	NA	2E+00
	Arsenic	1E-03	NA	3E+00	NA	NA	NA	NA	NA	NA	3E+00
	Barium	NA	NA	2E+00	NA	NA	NA	NA	NA	NA	2E+00
	Beryllium	NA	NA	7E-03	NA	NA	NA	NA	NA	NA	7E-03
	Cadmium	NA	NA	1E-01	NA	NA	NA	NA	NA	NA	1E-01
	Chromium	NA	NA	4E-04	NA	NA	NA	NA	NA	NA	4E-04
	Copper	NA	NA	3E-02	NA	NA	NA	NA	NA	NA	3E-02
	Lead	NA	NA	4E+00	NA	NA	NA	NA	NA	NA	4E+00
	Manganese	NA	NA	8E-01	NA	NA	NA	NA	NA	NA	8E-01
	Mercury	NA	NA	3E-04	NA	NA	NA	NA	NA	NA	3E-04
	Molybdenum	NA	NA	9E-01	NA	NA	NA	NA	NA	NA	9E-01
	Thallium	NA	NA	5E+00	NA	NA	NA	NA	NA	NA	5E+00
	Vanadium	NA	NA	1E+00	NA	NA	NA	NA	NA	NA	1E+00
	Zinc	4E-05	NA	1E-01	NA	NA	NA	NA	NA	NA	1E-01
BFR - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	4E-04	NA	NA	NA	NA	NA	NA	NA	NA	4E-04
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	4E-05	NA	NA	NA	NA	NA	NA	NA	NA	4E-05
SPC	Aluminum	NA	NA	2E+01	NA	NA	4E-03	NA	NA	NA	2E+01
	Antimony	NA	NA	3E+01	NA	NA	2E-01	NA	NA	NA	3E+01
	Arsenic	4E-04	NA	6E+00	NA	NA	2E-03	NA	NA	NA	6E+00
	Barium	NA	NA	1E+00	NA	NA	1E-03	NA	NA	NA	1E+00
	Beryllium	NA	NA	5E-03	NA	NA	1E-05	NA	NA	NA	5E-03
	Cadmium	NA	NA	1E-01	NA	NA	1E-03	NA	NA	NA	1E-01
	Chromium	NA	NA	2E-04	NA	NA	1E-06	NA	NA	NA	2E-04
	Copper	NA	NA	8E-03	NA	NA	1E-03	NA	NA	NA	9E-03
	Lead	NA	NA	7E+00	NA	NA	4E-04	NA	NA	NA	7E+00
	Manganese	NA	NA	4E-01	NA	NA	3E-04	NA	NA	NA	4E-01
	Mercury	NA	NA	2E-02	NA	NA	5E-06	NA	NA	NA	2E-02
	Molybdenum	NA	NA	2E-01	NA	NA	NA	NA	NA	NA	2E-01
	Thallium	NA	NA	6E+00	NA	NA	5E-03	NA	NA	NA	6E+00
	Vanadium	NA	NA	5E-01	NA	NA	2E-04	NA	NA	NA	5E-01
	Zinc	4E-05	NA	5E-02	NA	NA	8E-03	NA	NA	NA	6E-02

# APPENDIX L

## Great Horned Owl

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART A: HQ VALUES CALCULATED USING NOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
WWC - Reach A	Aluminum	NA	NA	3E-01	NA	2E-02	NA	NA	NA	NA	3E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	1E-03	NA	6E-05	NA	2E-04	NA	NA	NA	NA	2E-03
	Barium	NA	NA	2E-02	NA	1E-03	NA	NA	NA	NA	2E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	2E-03	NA	5E-04	NA	NA	NA	NA	2E-03
	Chromium	NA	NA	1E-02	NA	5E-03	NA	NA	NA	NA	2E-02
	Copper	NA	NA	7E-04	NA	4E-04	NA	NA	NA	NA	1E-03
	Lead	NA	NA	5E-03	NA	3E-04	NA	NA	NA	NA	5E-03
	Manganese	NA	NA	2E-03	NA	7E-05	NA	NA	NA	NA	2E-03
	Mercury	NA	NA	2E-03	NA	8E-06	NA	NA	NA	NA	2E-03
	Molybdenum	NA	NA	4E-05	NA	NA	NA	NA	NA	NA	4E-05
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	2E-03	NA	6E-05	NA	NA	NA	NA	2E-03
	Zinc	5E-03	NA	4E-04	NA	6E-04	NA	NA	NA	NA	6E-03
WWC - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	2E-03	NA	NA	NA	NA	NA	NA	NA	NA	2E-03
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	1E-02	NA	NA	NA	NA	NA	NA	NA	NA	1E-02
WWC - Reach C	Aluminum	NA	NA	3E-01	NA	3E-03	NA	NA	NA	3E-05	3E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	1E-02	NA	1E+00	NA	2E-03	NA	NA	NA	3E-04	1E+00
	Barium	NA	NA	1E-02	NA	5E-04	NA	NA	NA	5E-06	1E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	3E-03	NA	4E-04	NA	NA	NA	2E-06	3E-03
	Chromium	NA	NA	2E-02	NA	4E-03	NA	NA	NA	1E-04	2E-02
	Copper	NA	NA	4E-03	NA	5E-04	NA	NA	NA	9E-06	5E-03
	Lead	NA	NA	8E-03	NA	6E-05	NA	NA	NA	2E-05	8E-03
	Manganese	NA	NA	5E-03	NA	4E-05	NA	NA	NA	1E-06	5E-03
	Mercury	NA	NA	4E-03	NA	2E-04	NA	NA	NA	4E-05	4E-03
	Molybdenum	NA	NA	3E-04	NA	NA	NA	NA	NA	NA	3E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	3E-03	NA	3E-05	NA	NA	NA	2E-06	3E-03
	Zinc	3E-04	NA	8E-04	NA	7E-04	NA	NA	NA	5E-05	2E-03
WWC - Reach D	Aluminum	NA	NA	3E-01	NA	7E-03	NA	NA	NA	1E-04	3E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	2E-02	NA	7E-01	NA	2E-03	NA	NA	NA	1E-04	7E-01
	Barium	NA	NA	1E-02	NA	5E-04	NA	NA	NA	1E-05	1E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	4E-03	NA	5E-04	NA	NA	NA	9E-06	5E-03
	Chromium	NA	NA	2E-02	NA	5E-03	NA	NA	NA	1E-04	2E-02
	Copper	NA	NA	3E-03	NA	6E-04	NA	NA	NA	5E-06	3E-03
	Lead	NA	NA	5E-03	NA	8E-05	NA	NA	NA	8E-07	5E-03
	Manganese	NA	NA	5E-03	NA	3E-05	NA	NA	NA	2E-05	5E-03
	Mercury	NA	NA	2E-03	NA	2E-04	NA	NA	NA	4E-05	2E-03
	Molybdenum	NA	NA	2E-04	NA	NA	NA	NA	NA	NA	2E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	3E-03	NA	4E-05	NA	NA	NA	4E-06	3E-03
	Zinc	1E-03	NA	6E-04	NA	9E-04	NA	NA	NA	4E-05	2E-03

# APPENDIX L

## Great Horned Owl

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART A: HQ VALUES CALCULATED USING NOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
BFR - Reach A	Aluminum	NA	NA	3E-01	NA	NA	NA	NA	NA	7E-04	3E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	7E-04	NA	3E-03	NA	NA	NA	NA	NA	2E-05	4E-03
	Barium	NA	NA	1E-02	NA	NA	NA	NA	NA	3E-05	1E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	3E-03	NA	NA	NA	NA	NA	6E-06	3E-03
	Chromium	NA	NA	1E-02	NA	NA	NA	NA	NA	1E-04	1E-02
	Copper	NA	NA	1E-03	NA	NA	NA	NA	NA	6E-06	1E-03
	Lead	NA	NA	4E-03	NA	NA	NA	NA	NA	3E-06	4E-03
	Manganese	NA	NA	2E-03	NA	NA	NA	NA	NA	4E-06	2E-03
	Mercury	NA	NA	7E-05	NA	NA	NA	NA	NA	3E-05	1E-04
	Molybdenum	NA	NA	3E-04	NA	NA	NA	NA	NA	NA	3E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	3E-03	NA	NA	NA	NA	NA	8E-06	3E-03
	Zinc	2E-05	NA	7E-04	NA	NA	NA	NA	NA	5E-05	7E-04
BFR - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	4E-04	4E-04
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	2E-04	NA	NA	NA	NA	NA	NA	NA	6E-05	3E-04
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	1E-05	1E-05
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	6E-06	6E-06
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	1E-04	1E-04
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	7E-06	7E-06
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	2E-06	2E-06
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	7E-06	7E-06
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	5E-05	5E-05
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	6E-06	6E-06
	Zinc	2E-05	NA	NA	NA	NA	NA	NA	NA	7E-05	9E-05
SPC	Aluminum	NA	NA	1E-01	NA	4E-03	NA	NA	NA	8E-05	1E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	2E-04	NA	7E-03	NA	2E-04	NA	NA	NA	7E-06	8E-03
	Barium	NA	NA	9E-03	NA	8E-04	NA	NA	NA	9E-06	1E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	5E-03	NA	4E-04	NA	NA	NA	3E-06	5E-03
	Chromium	NA	NA	7E-03	NA	4E-03	NA	NA	NA	4E-04	1E-02
	Copper	NA	NA	4E-04	NA	5E-04	NA	NA	NA	5E-06	9E-04
	Lead	NA	NA	6E-03	NA	6E-04	NA	NA	NA	1E-06	7E-03
	Manganese	NA	NA	1E-03	NA	4E-05	NA	NA	NA	7E-07	1E-03
	Mercury	NA	NA	4E-03	NA	5E-04	NA	NA	NA	3E-05	5E-03
	Molybdenum	NA	NA	7E-05	NA	NA	NA	NA	NA	NA	7E-05
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	1E-03	NA	5E-05	NA	NA	NA	3E-06	1E-03
	Zinc	2E-05	NA	3E-04	NA	8E-04	NA	NA	NA	5E-05	1E-03

# APPENDIX L

## Great Horned Owl

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART B: HQ VALUES CALCULATED USING LOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
WWC - Reach A	Aluminum	NA	NA	6E-02	NA	4E-03	NA	NA	NA	NA	7E-02
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	1E-04	NA	7E-06	NA	3E-05	NA	NA	NA	NA	2E-04
	Barium	NA	NA	1E-02	NA	7E-04	NA	NA	NA	NA	1E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	6E-05	NA	2E-05	NA	NA	NA	NA	7E-05
	Chromium	NA	NA	3E-03	NA	1E-03	NA	NA	NA	NA	4E-03
	Copper	NA	NA	5E-04	NA	2E-04	NA	NA	NA	NA	7E-04
	Lead	NA	NA	2E-03	NA	1E-04	NA	NA	NA	NA	2E-03
	Manganese	NA	NA	5E-04	NA	2E-05	NA	NA	NA	NA	5E-04
	Mercury	NA	NA	1E-03	NA	4E-06	NA	NA	NA	NA	1E-03
	Molybdenum	NA	NA	1E-05	NA	NA	NA	NA	NA	NA	1E-05
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	5E-04	NA	2E-05	NA	NA	NA	NA	6E-04
	Zinc	2E-03	NA	1E-04	NA	2E-04	NA	NA	NA	NA	2E-03

WWC - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	2E-04	NA	NA	NA	NA	NA	NA	NA	NA	2E-04
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	4E-03	NA	NA	NA	NA	NA	NA	NA	NA	4E-03

WWC - Reach C	Aluminum	NA	NA	6E-02	NA	5E-04	NA	NA	NA	5E-06	6E-02
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	1E-03	NA	1E-01	NA	2E-04	NA	NA	NA	3E-05	1E-01
	Barium	NA	NA	7E-03	NA	3E-04	NA	NA	NA	3E-06	7E-03
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	1E-04	NA	1E-05	NA	NA	NA	9E-08	1E-04
	Chromium	NA	NA	3E-03	NA	9E-04	NA	NA	NA	2E-05	4E-03
	Copper	NA	NA	3E-03	NA	3E-04	NA	NA	NA	6E-06	3E-03
	Lead	NA	NA	4E-03	NA	3E-05	NA	NA	NA	1E-05	4E-03
	Manganese	NA	NA	2E-03	NA	1E-05	NA	NA	NA	3E-07	2E-03
	Mercury	NA	NA	2E-03	NA	9E-05	NA	NA	NA	2E-05	2E-03
	Molybdenum	NA	NA	9E-05	NA	NA	NA	NA	NA	NA	9E-05
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	1E-03	NA	1E-05	NA	NA	NA	6E-07	1E-03
	Zinc	1E-04	NA	3E-04	NA	2E-04	NA	NA	NA	2E-05	6E-04

WWC - Reach D	Aluminum	NA	NA	6E-02	NA	1E-03	NA	NA	NA	3E-05	6E-02
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	2E-03	NA	8E-02	NA	2E-04	NA	NA	NA	1E-05	8E-02
	Barium	NA	NA	6E-03	NA	3E-04	NA	NA	NA	6E-06	6E-03
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	1E-04	NA	2E-05	NA	NA	NA	3E-07	2E-04
	Chromium	NA	NA	3E-03	NA	9E-04	NA	NA	NA	2E-05	4E-03
	Copper	NA	NA	2E-03	NA	4E-04	NA	NA	NA	4E-06	2E-03
	Lead	NA	NA	2E-03	NA	4E-05	NA	NA	NA	4E-07	2E-03
	Manganese	NA	NA	2E-03	NA	1E-05	NA	NA	NA	5E-06	2E-03
	Mercury	NA	NA	1E-03	NA	8E-05	NA	NA	NA	2E-05	1E-03
	Molybdenum	NA	NA	5E-05	NA	NA	NA	NA	NA	NA	5E-05
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	9E-04	NA	1E-05	NA	NA	NA	1E-06	9E-04
	Zinc	3E-04	NA	2E-04	NA	3E-04	NA	NA	NA	1E-05	8E-04

# APPENDIX L

## Great Horned Owl

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART B: HQ VALUES CALCULATED USING LOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
BFR - Reach A	Aluminum	NA	NA	6E-02	NA	NA	NA	NA	NA	1E-04	6E-02
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	8E-05	NA	4E-04	NA	NA	NA	NA	NA	2E-06	5E-04
	Barium	NA	NA	6E-03	NA	NA	NA	NA	NA	1E-05	6E-03
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	1E-04	NA	NA	NA	NA	NA	2E-07	1E-04
	Chromium	NA	NA	2E-03	NA	NA	NA	NA	NA	3E-05	3E-03
	Copper	NA	NA	9E-04	NA	NA	NA	NA	NA	4E-06	9E-04
	Lead	NA	NA	2E-03	NA	NA	NA	NA	NA	1E-06	2E-03
	Manganese	NA	NA	7E-04	NA	NA	NA	NA	NA	1E-06	7E-04
	Mercury	NA	NA	3E-05	NA	NA	NA	NA	NA	2E-05	5E-05
	Molybdenum	NA	NA	1E-04	NA	NA	NA	NA	NA	NA	1E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	1E-03	NA	NA	NA	NA	NA	3E-06	1E-03
	Zinc	7E-06	NA	2E-04	NA	NA	NA	NA	NA	2E-05	2E-04
BFR - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	8E-05	8E-05
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	3E-05	NA	NA	NA	NA	NA	NA	NA	7E-06	4E-05
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	7E-06	7E-06
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	2E-07	2E-07
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	3E-05	3E-05
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	5E-06	5E-06
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	9E-07	9E-07
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	2E-06	2E-06
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	2E-05	2E-05
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	2E-06	2E-06
	Zinc	7E-06	NA	NA	NA	NA	NA	NA	NA	2E-05	3E-05
SPC	Aluminum	NA	NA	2E-02	NA	9E-04	NA	NA	NA	2E-05	2E-02
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	3E-05	NA	9E-04	NA	2E-05	NA	NA	NA	8E-07	9E-04
	Barium	NA	NA	4E-03	NA	4E-04	NA	NA	NA	4E-06	5E-03
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	2E-04	NA	1E-05	NA	NA	NA	1E-07	2E-04
	Chromium	NA	NA	1E-03	NA	8E-04	NA	NA	NA	9E-05	2E-03
	Copper	NA	NA	3E-04	NA	3E-04	NA	NA	NA	3E-06	6E-04
	Lead	NA	NA	3E-03	NA	3E-04	NA	NA	NA	7E-07	3E-03
	Manganese	NA	NA	3E-04	NA	1E-05	NA	NA	NA	2E-07	3E-04
	Mercury	NA	NA	2E-03	NA	3E-04	NA	NA	NA	2E-05	3E-03
	Molybdenum	NA	NA	2E-05	NA	NA	NA	NA	NA	NA	2E-05
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	4E-04	NA	2E-05	NA	NA	NA	1E-06	4E-04
	Zinc	7E-06	NA	9E-05	NA	3E-04	NA	NA	NA	2E-05	4E-04

# APPENDIX L

## Deer Mouse

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART A: HQ VALUES CALCULATED USING NOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
WWC - Reach A	Aluminum	NA	NA	1E+01	1E-01	NA	8E-04	9E-04	NA	NA	1E+01
	Antimony	NA	NA	4E-01	1E-02	NA	3E-03	4E-03	NA	NA	4E-01
	Arsenic	1E-03	NA	3E-04	4E-04	NA	2E-06	4E-03	NA	NA	6E-03
	Barium	NA	NA	3E-01	2E-02	NA	7E-05	4E-04	NA	NA	3E-01
	Beryllium	NA	NA	4E-03	8E-05	NA	7E-07	4E-06	NA	NA	4E-03
	Cadmium	NA	NA	2E-03	8E-04	NA	8E-06	1E-04	NA	NA	3E-03
	Chromium	NA	NA	5E-05	9E-07	NA	2E-07	1E-07	NA	NA	5E-05
	Copper	NA	NA	2E-04	4E-05	NA	8E-06	3E-06	NA	NA	3E-04
	Lead	NA	NA	1E-01	3E-03	NA	2E-05	8E-05	NA	NA	1E-01
	Manganese	NA	NA	8E-02	4E-02	NA	2E-04	8E-05	NA	NA	1E-01
	Mercury	NA	NA	4E-04	3E-05	NA	1E-07	6E-06	NA	NA	5E-04
	Molybdenum	NA	NA	1E-01	NA	NA	NA	NA	NA	NA	1E-01
	Thallium	NA	NA	2E-01	9E-02	NA	1E-04	4E-02	NA	NA	4E-01
	Vanadium	NA	NA	5E-02	1E-03	NA	2E-05	1E-04	NA	NA	5E-02
	Zinc	9E-03	NA	3E-03	9E-04	NA	2E-04	1E-04	NA	NA	1E-02
WWC - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	2E-03	NA	NA	NA	NA	NA	NA	NA	NA	2E-03
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	3E-02	NA	NA	NA	NA	NA	NA	NA	NA	3E-02
WWC - Reach C	Aluminum	NA	NA	1E+01	3E-02	NA	2E-03	2E-03	NA	NA	1E+01
	Antimony	NA	NA	1E+00	8E-03	NA	3E-03	6E-04	NA	NA	1E+00
	Arsenic	9E-03	NA	5E+00	6E-03	NA	7E-05	7E-03	NA	NA	5E+00
	Barium	NA	NA	2E-01	6E-03	NA	2E-05	8E-05	NA	NA	2E-01
	Beryllium	NA	NA	7E-04	6E-05	NA	7E-07	4E-06	NA	NA	8E-04
	Cadmium	NA	NA	4E-03	9E-04	NA	4E-05	2E-04	NA	NA	6E-03
	Chromium	NA	NA	6E-05	9E-07	NA	8E-07	1E-07	NA	NA	6E-05
	Copper	NA	NA	1E-03	4E-05	NA	1E-05	4E-06	NA	NA	1E-03
	Lead	NA	NA	2E-01	7E-04	NA	6E-06	3E-05	NA	NA	2E-01
	Manganese	NA	NA	2E-01	7E-03	NA	3E-05	7E-05	NA	NA	2E-01
	Mercury	NA	NA	8E-04	1E-05	NA	9E-08	2E-06	NA	NA	8E-04
	Molybdenum	NA	NA	8E-01	NA	NA	NA	NA	NA	NA	8E-01
	Thallium	NA	NA	1E+00	6E-02	NA	1E-04	4E-03	NA	NA	1E+00
	Vanadium	NA	NA	9E-02	9E-04	NA	6E-06	3E-05	NA	NA	9E-02
	Zinc	6E-04	NA	7E-03	9E-04	NA	2E-04	1E-04	NA	NA	9E-03
WWC - Reach D	Aluminum	NA	NA	1E+01	3E-02	NA	7E-04	7E-03	NA	NA	1E+01
	Antimony	NA	NA	1E+00	6E-03	NA	3E-03	6E-04	NA	NA	1E+00
	Arsenic	1E-02	NA	3E+00	2E-03	NA	3E-04	8E-03	NA	NA	3E+00
	Barium	NA	NA	1E-01	1E-02	NA	3E-05	1E-04	NA	NA	2E-01
	Beryllium	NA	NA	7E-04	5E-05	NA	7E-07	4E-06	NA	NA	8E-04
	Cadmium	NA	NA	6E-03	5E-04	NA	2E-05	2E-04	NA	NA	7E-03
	Chromium	NA	NA	5E-05	2E-06	NA	2E-07	2E-07	NA	NA	6E-05
	Copper	NA	NA	9E-04	3E-05	NA	9E-06	3E-06	NA	NA	1E-03
	Lead	NA	NA	1E-01	4E-04	NA	4E-06	8E-05	NA	NA	1E-01
	Manganese	NA	NA	3E-01	3E-02	NA	4E-05	2E-04	NA	NA	3E-01
	Mercury	NA	NA	4E-04	8E-06	NA	9E-08	2E-06	NA	NA	4E-04
	Molybdenum	NA	NA	5E-01	NA	NA	NA	NA	NA	NA	5E-01
	Thallium	NA	NA	1E+00	5E-02	NA	1E-04	4E-03	NA	NA	1E+00
	Vanadium	NA	NA	8E-02	7E-04	NA	2E-05	6E-05	NA	NA	8E-02
	Zinc	2E-03	NA	5E-03	8E-04	NA	2E-04	1E-04	NA	NA	8E-03

# APPENDIX L

## Deer Mouse

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART A: HQ VALUES CALCULATED USING NOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
BFR - Reach A	Aluminum	NA	NA	1E+01	NA	NA	NA	NA	NA	NA	1E+01
	Antimony	NA	NA	5E-02	NA	NA	NA	NA	NA	NA	5E-02
	Arsenic	7E-04	NA	2E-02	NA	NA	NA	NA	NA	NA	2E-02
	Barium	NA	NA	1E-01	NA	NA	NA	NA	NA	NA	1E-01
	Beryllium	NA	NA	9E-04	NA	NA	NA	NA	NA	NA	9E-04
	Cadmium	NA	NA	5E-03	NA	NA	NA	NA	NA	NA	5E-03
	Chromium	NA	NA	4E-05	NA	NA	NA	NA	NA	NA	4E-05
	Copper	NA	NA	4E-04	NA	NA	NA	NA	NA	NA	4E-04
	Lead	NA	NA	1E-01	NA	NA	NA	NA	NA	NA	1E-01
	Manganese	NA	NA	1E-01	NA	NA	NA	NA	NA	NA	1E-01
	Mercury	NA	NA	1E-05	NA	NA	NA	NA	NA	NA	1E-05
	Molybdenum	NA	NA	9E-01	NA	NA	NA	NA	NA	NA	9E-01
	Thallium	NA	NA	4E-01	NA	NA	NA	NA	NA	NA	4E-01
	Vanadium	NA	NA	1E-01	NA	NA	NA	NA	NA	NA	1E-01
	Zinc	4E-05	NA	6E-03	NA	NA	NA	NA	NA	NA	6E-03
BFR - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	2E-04	NA	NA	NA	NA	NA	NA	NA	NA	2E-04
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	4E-05	NA	NA	NA	NA	NA	NA	NA	NA	4E-05
SPC	Aluminum	NA	NA	5E+00	6E-02	NA	3E-04	NA	NA	NA	5E+00
	Antimony	NA	NA	8E-01	7E-03	NA	3E-03	NA	NA	NA	8E-01
	Arsenic	2E-04	NA	3E-02	3E-04	NA	5E-06	NA	NA	NA	3E-02
	Barium	NA	NA	1E-01	1E-02	NA	3E-05	NA	NA	NA	1E-01
	Beryllium	NA	NA	6E-04	5E-05	NA	7E-07	NA	NA	NA	6E-04
	Cadmium	NA	NA	7E-03	6E-04	NA	2E-05	NA	NA	NA	8E-03
	Chromium	NA	NA	2E-05	1E-06	NA	6E-08	NA	NA	NA	3E-05
	Copper	NA	NA	1E-04	4E-05	NA	7E-06	NA	NA	NA	2E-04
	Lead	NA	NA	2E-01	3E-03	NA	3E-06	NA	NA	NA	2E-01
	Manganese	NA	NA	5E-02	3E-03	NA	2E-05	NA	NA	NA	5E-02
	Mercury	NA	NA	9E-04	8E-06	NA	9E-08	NA	NA	NA	9E-04
	Molybdenum	NA	NA	2E-01	NA	NA	NA	NA	NA	NA	2E-01
	Thallium	NA	NA	4E-01	6E-02	NA	1E-04	NA	NA	NA	5E-01
	Vanadium	NA	NA	4E-02	8E-04	NA	6E-06	NA	NA	NA	4E-02
	Zinc	4E-05	NA	3E-03	8E-04	NA	1E-04	NA	NA	NA	4E-03

# APPENDIX L

## Deer Mouse

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART B: HQ VALUES CALCULATED USING LOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
WWC - Reach A	Aluminum	NA	NA	3E+00	3E-02	NA	2E-04	2E-04	NA	NA	3E+00
	Antimony	NA	NA	1E-01	4E-03	NA	9E-04	1E-03	NA	NA	1E-01
	Arsenic	4E-04	NA	9E-05	1E-04	NA	6E-07	1E-03	NA	NA	2E-03
	Barium	NA	NA	9E-02	8E-03	NA	2E-05	1E-04	NA	NA	1E-01
	Beryllium	NA	NA	1E-03	3E-05	NA	2E-07	1E-06	NA	NA	1E-03
	Cadmium	NA	NA	1E-03	4E-04	NA	4E-06	6E-05	NA	NA	2E-03
	Chromium	NA	NA	2E-05	3E-07	NA	6E-08	4E-08	NA	NA	2E-05
	Copper	NA	NA	1E-04	2E-05	NA	4E-06	2E-06	NA	NA	1E-04
	Lead	NA	NA	5E-02	9E-04	NA	6E-06	3E-05	NA	NA	5E-02
	Manganese	NA	NA	2E-02	1E-02	NA	5E-05	3E-05	NA	NA	4E-02
	Mercury	NA	NA	1E-04	9E-06	NA	3E-08	2E-06	NA	NA	2E-04
	Molybdenum	NA	NA	5E-03	NA	NA	NA	NA	NA	NA	5E-03
	Thallium	NA	NA	8E-02	3E-02	NA	5E-05	1E-02	NA	NA	1E-01
	Vanadium	NA	NA	2E-02	4E-04	NA	7E-06	4E-05	NA	NA	2E-02
	Zinc	5E-03	NA	2E-03	5E-04	NA	9E-05	6E-05	NA	NA	7E-03

WWC - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	6E-04	NA	NA	NA	NA	NA	NA	NA	NA	6E-04
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	1E-02	NA	NA	NA	NA	NA	NA	NA	NA	1E-02

WWC - Reach C	Aluminum	NA	NA	3E+00	7E-03	NA	3E-04	4E-04	NA	NA	3E+00
	Antimony	NA	NA	3E-01	3E-03	NA	9E-04	2E-04	NA	NA	3E-01
	Arsenic	3E-03	NA	2E+00	2E-03	NA	2E-05	2E-03	NA	NA	2E+00
	Barium	NA	NA	5E-02	2E-03	NA	8E-06	3E-05	NA	NA	6E-02
	Beryllium	NA	NA	2E-04	2E-05	NA	2E-07	1E-06	NA	NA	3E-04
	Cadmium	NA	NA	2E-03	5E-04	NA	2E-05	1E-04	NA	NA	3E-03
	Chromium	NA	NA	2E-05	3E-07	NA	3E-07	5E-08	NA	NA	2E-05
	Copper	NA	NA	7E-04	2E-05	NA	5E-06	2E-06	NA	NA	7E-04
	Lead	NA	NA	8E-02	2E-04	NA	2E-06	1E-05	NA	NA	8E-02
	Manganese	NA	NA	7E-02	2E-03	NA	1E-05	2E-05	NA	NA	8E-02
	Mercury	NA	NA	3E-04	3E-06	NA	3E-08	7E-07	NA	NA	3E-04
	Molybdenum	NA	NA	3E-02	NA	NA	NA	NA	NA	NA	3E-02
	Thallium	NA	NA	4E-01	2E-02	NA	5E-05	1E-03	NA	NA	4E-01
	Vanadium	NA	NA	3E-02	3E-04	NA	2E-06	1E-05	NA	NA	3E-02
	Zinc	3E-04	NA	4E-03	4E-04	NA	8E-05	6E-05	NA	NA	4E-03

WWC - Reach D	Aluminum	NA	NA	3E+00	6E-03	NA	1E-04	1E-03	NA	NA	3E+00
	Antimony	NA	NA	4E-01	2E-03	NA	9E-04	2E-04	NA	NA	4E-01
	Arsenic	5E-03	NA	1E+00	7E-04	NA	9E-05	3E-03	NA	NA	1E+00
	Barium	NA	NA	5E-02	4E-03	NA	9E-06	4E-05	NA	NA	5E-02
	Beryllium	NA	NA	2E-04	2E-05	NA	2E-07	1E-06	NA	NA	3E-04
	Cadmium	NA	NA	3E-03	2E-04	NA	1E-05	1E-04	NA	NA	3E-03
	Chromium	NA	NA	2E-05	6E-07	NA	8E-08	6E-08	NA	NA	2E-05
	Copper	NA	NA	4E-04	2E-05	NA	4E-06	1E-06	NA	NA	5E-04
	Lead	NA	NA	5E-02	1E-04	NA	1E-06	3E-05	NA	NA	5E-02
	Manganese	NA	NA	8E-02	8E-03	NA	1E-05	7E-05	NA	NA	9E-02
	Mercury	NA	NA	1E-04	3E-06	NA	3E-08	8E-07	NA	NA	1E-04
	Molybdenum	NA	NA	2E-02	NA	NA	NA	NA	NA	NA	2E-02
	Thallium	NA	NA	4E-01	2E-02	NA	5E-05	1E-03	NA	NA	4E-01
	Vanadium	NA	NA	3E-02	2E-04	NA	7E-06	2E-05	NA	NA	3E-02
	Zinc	1E-03	NA	3E-03	4E-04	NA	8E-05	6E-05	NA	NA	4E-03

# APPENDIX L

## Deer Mouse

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART B: HQ VALUES CALCULATED USING LOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
BFR - Reach A	Aluminum	NA	NA	3E+00	NA	NA	NA	NA	NA	NA	3E+00
	Antimony	NA	NA	2E-02	NA	NA	NA	NA	NA	NA	2E-02
	Arsenic	2E-04	NA	5E-03	NA	NA	NA	NA	NA	NA	5E-03
	Barium	NA	NA	5E-02	NA	NA	NA	NA	NA	NA	5E-02
	Beryllium	NA	NA	3E-04	NA	NA	NA	NA	NA	NA	3E-04
	Cadmium	NA	NA	2E-03	NA	NA	NA	NA	NA	NA	2E-03
	Chromium	NA	NA	1E-05	NA	NA	NA	NA	NA	NA	1E-05
	Copper	NA	NA	2E-04	NA	NA	NA	NA	NA	NA	2E-04
	Lead	NA	NA	4E-02	NA	NA	NA	NA	NA	NA	4E-02
	Manganese	NA	NA	3E-02	NA	NA	NA	NA	NA	NA	3E-02
	Mercury	NA	NA	4E-06	NA	NA	NA	NA	NA	NA	4E-06
	Molybdenum	NA	NA	4E-02	NA	NA	NA	NA	NA	NA	4E-02
	Thallium	NA	NA	1E-01	NA	NA	NA	NA	NA	NA	1E-01
	Vanadium	NA	NA	3E-02	NA	NA	NA	NA	NA	NA	3E-02
	Zinc	2E-05	NA	3E-03	NA	NA	NA	NA	NA	NA	3E-03

BFR - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	8E-05	NA	NA	NA	NA	NA	NA	NA	NA	8E-05
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	2E-05	NA	NA	NA	NA	NA	NA	NA	NA	2E-05

SPC	Aluminum	NA	NA	1E+00	1E-02	NA	7E-05	NA	NA	NA	1E+00
	Antimony	NA	NA	3E-01	2E-03	NA	9E-04	NA	NA	NA	3E-01
	Arsenic	8E-05	NA	1E-02	1E-04	NA	2E-06	NA	NA	NA	1E-02
	Barium	NA	NA	3E-02	4E-03	NA	1E-05	NA	NA	NA	4E-02
	Beryllium	NA	NA	2E-04	2E-05	NA	2E-07	NA	NA	NA	2E-04
	Cadmium	NA	NA	4E-03	3E-04	NA	1E-05	NA	NA	NA	4E-03
	Chromium	NA	NA	8E-06	3E-07	NA	2E-08	NA	NA	NA	9E-06
	Copper	NA	NA	7E-05	2E-05	NA	3E-06	NA	NA	NA	9E-05
	Lead	NA	NA	6E-02	1E-03	NA	1E-06	NA	NA	NA	6E-02
	Manganese	NA	NA	2E-02	1E-03	NA	5E-06	NA	NA	NA	2E-02
	Mercury	NA	NA	3E-04	3E-06	NA	3E-08	NA	NA	NA	3E-04
	Molybdenum	NA	NA	9E-03	NA	NA	NA	NA	NA	NA	9E-03
	Thallium	NA	NA	1E-01	2E-02	NA	5E-05	NA	NA	NA	2E-01
	Vanadium	NA	NA	1E-02	3E-04	NA	2E-06	NA	NA	NA	1E-02
	Zinc	2E-05	NA	1E-03	4E-04	NA	7E-05	NA	NA	NA	2E-03

# APPENDIX L

## Cliff Swallow

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART A: HQ VALUES CALCULATED USING NOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
WWC - Reach A	Aluminum	NA	NA	5E+00	NA	NA	4E-03	NA	NA	NA	5E+00
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	5E-03	NA	9E-04	NA	NA	1E-04	NA	NA	NA	6E-03
	Barium	NA	NA	3E-01	NA	NA	1E-03	NA	NA	NA	4E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	2E-02	NA	NA	1E-03	NA	NA	NA	3E-02
	Chromium	NA	NA	2E-01	NA	NA	1E-02	NA	NA	NA	2E-01
	Copper	NA	NA	1E-02	NA	NA	6E-03	NA	NA	NA	2E-02
	Lead	NA	NA	7E-02	NA	NA	2E-04	NA	NA	NA	7E-02
	Manganese	NA	NA	2E-02	NA	NA	7E-04	NA	NA	NA	2E-02
	Mercury	NA	NA	3E-02	NA	NA	1E-04	NA	NA	NA	3E-02
	Molybdenum	NA	NA	6E-04	NA	NA	NA	NA	NA	NA	6E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	2E-02	NA	NA	2E-04	NA	NA	NA	3E-02
	Zinc	2E-02	NA	6E-03	NA	NA	5E-03	NA	NA	NA	3E-02
WWC - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	8E-03	NA	NA	NA	NA	NA	NA	NA	NA	8E-03
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	6E-02	NA	NA	NA	NA	NA	NA	NA	NA	6E-02
WWC - Reach C	Aluminum	NA	NA	5E+00	NA	NA	9E-03	NA	NA	NA	5E+00
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	4E-02	NA	2E+01	NA	NA	4E-03	NA	NA	NA	2E+01
	Barium	NA	NA	2E-01	NA	NA	5E-04	NA	NA	NA	2E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	5E-02	NA	NA	6E-03	NA	NA	NA	5E-02
	Chromium	NA	NA	3E-01	NA	NA	5E-02	NA	NA	NA	3E-01
	Copper	NA	NA	7E-02	NA	NA	7E-03	NA	NA	NA	7E-02
	Lead	NA	NA	1E-01	NA	NA	4E-05	NA	NA	NA	1E-01
	Manganese	NA	NA	7E-02	NA	NA	2E-04	NA	NA	NA	7E-02
	Mercury	NA	NA	6E-02	NA	NA	1E-04	NA	NA	NA	6E-02
	Molybdenum	NA	NA	4E-03	NA	NA	NA	NA	NA	NA	4E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	5E-02	NA	NA	5E-05	NA	NA	NA	5E-02
	Zinc	1E-03	NA	1E-02	NA	NA	4E-03	NA	NA	NA	2E-02
WWC - Reach D	Aluminum	NA	NA	5E+00	NA	NA	4E-03	NA	NA	NA	5E+00
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	7E-02	NA	1E+01	NA	NA	1E-02	NA	NA	NA	1E+01
	Barium	NA	NA	2E-01	NA	NA	5E-04	NA	NA	NA	2E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	6E-02	NA	NA	4E-03	NA	NA	NA	7E-02
	Chromium	NA	NA	2E-01	NA	NA	2E-02	NA	NA	NA	3E-01
	Copper	NA	NA	4E-02	NA	NA	6E-03	NA	NA	NA	5E-02
	Lead	NA	NA	8E-02	NA	NA	4E-05	NA	NA	NA	8E-02
	Manganese	NA	NA	7E-02	NA	NA	2E-04	NA	NA	NA	7E-02
	Mercury	NA	NA	3E-02	NA	NA	1E-04	NA	NA	NA	3E-02
	Molybdenum	NA	NA	3E-03	NA	NA	NA	NA	NA	NA	3E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	4E-02	NA	NA	2E-04	NA	NA	NA	4E-02
	Zinc	4E-03	NA	9E-03	NA	NA	4E-03	NA	NA	NA	2E-02

# APPENDIX L

## Cliff Swallow

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART A: HQ VALUES CALCULATED USING NOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
BFR - Reach A	Aluminum	NA	NA	4E+00	NA	NA	NA	NA	NA	NA	4E+00
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	3E-03	NA	5E-02	NA	NA	NA	NA	NA	NA	5E-02
	Barium	NA	NA	2E-01	NA	NA	NA	NA	NA	NA	2E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	5E-02	NA	NA	NA	NA	NA	NA	5E-02
	Chromium	NA	NA	2E-01	NA	NA	NA	NA	NA	NA	2E-01
	Copper	NA	NA	2E-02	NA	NA	NA	NA	NA	NA	2E-02
	Lead	NA	NA	6E-02	NA	NA	NA	NA	NA	NA	6E-02
	Manganese	NA	NA	3E-02	NA	NA	NA	NA	NA	NA	3E-02
	Mercury	NA	NA	1E-03	NA	NA	NA	NA	NA	NA	1E-03
	Molybdenum	NA	NA	5E-03	NA	NA	NA	NA	NA	NA	5E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	5E-02	NA	NA	NA	NA	NA	NA	5E-02
	Zinc	9E-05	NA	1E-02	NA	NA	NA	NA	NA	NA	1E-02
BFR - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	1E-03	NA	NA	NA	NA	NA	NA	NA	NA	1E-03
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	9E-05	NA	NA	NA	NA	NA	NA	NA	NA	9E-05
SPC	Aluminum	NA	NA	2E+00	NA	NA	2E-03	NA	NA	NA	2E+00
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	1E-03	NA	1E-01	NA	NA	3E-04	NA	NA	NA	1E-01
	Barium	NA	NA	1E-01	NA	NA	6E-04	NA	NA	NA	1E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	8E-02	NA	NA	4E-03	NA	NA	NA	8E-02
	Chromium	NA	NA	1E-01	NA	NA	4E-03	NA	NA	NA	1E-01
	Copper	NA	NA	7E-03	NA	NA	5E-03	NA	NA	NA	1E-02
	Lead	NA	NA	9E-02	NA	NA	3E-05	NA	NA	NA	9E-02
	Manganese	NA	NA	1E-02	NA	NA	8E-05	NA	NA	NA	1E-02
	Mercury	NA	NA	7E-02	NA	NA	1E-04	NA	NA	NA	7E-02
	Molybdenum	NA	NA	1E-03	NA	NA	NA	NA	NA	NA	1E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	2E-02	NA	NA	5E-05	NA	NA	NA	2E-02
	Zinc	9E-05	NA	4E-03	NA	NA	4E-03	NA	NA	NA	8E-03

# APPENDIX L

## Cliff Swallow

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART B: HQ VALUES CALCULATED USING LOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
WWC - Reach A	Aluminum	NA	NA	1E+00	NA	NA	9E-04	NA	NA	NA	1E+00
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	6E-04	NA	1E-04	NA	NA	1E-05	NA	NA	NA	7E-04
	Barium	NA	NA	2E-01	NA	NA	7E-04	NA	NA	NA	2E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	9E-04	NA	NA	5E-05	NA	NA	NA	9E-04
	Chromium	NA	NA	4E-02	NA	NA	2E-03	NA	NA	NA	5E-02
	Copper	NA	NA	7E-03	NA	NA	4E-03	NA	NA	NA	1E-02
	Lead	NA	NA	4E-02	NA	NA	8E-05	NA	NA	NA	4E-02
	Manganese	NA	NA	8E-03	NA	NA	2E-04	NA	NA	NA	8E-03
	Mercury	NA	NA	2E-02	NA	NA	7E-05	NA	NA	NA	2E-02
	Molybdenum	NA	NA	2E-04	NA	NA	NA	NA	NA	NA	2E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	8E-03	NA	NA	6E-05	NA	NA	NA	8E-03
	Zinc	7E-03	NA	2E-03	NA	NA	2E-03	NA	NA	NA	1E-02
WWC - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	1E-03	NA	NA	NA	NA	NA	NA	NA	NA	1E-03
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	2E-02	NA	NA	NA	NA	NA	NA	NA	NA	2E-02
WWC - Reach C	Aluminum	NA	NA	9E-01	NA	NA	2E-03	NA	NA	NA	9E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	5E-03	NA	2E+00	NA	NA	4E-04	NA	NA	NA	2E+00
	Barium	NA	NA	1E-01	NA	NA	3E-04	NA	NA	NA	1E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	2E-03	NA	NA	2E-04	NA	NA	NA	2E-03
	Chromium	NA	NA	5E-02	NA	NA	1E-02	NA	NA	NA	6E-02
	Copper	NA	NA	4E-02	NA	NA	5E-03	NA	NA	NA	5E-02
	Lead	NA	NA	6E-02	NA	NA	2E-05	NA	NA	NA	6E-02
	Manganese	NA	NA	2E-02	NA	NA	5E-05	NA	NA	NA	2E-02
	Mercury	NA	NA	3E-02	NA	NA	6E-05	NA	NA	NA	3E-02
	Molybdenum	NA	NA	1E-03	NA	NA	NA	NA	NA	NA	1E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	2E-02	NA	NA	2E-05	NA	NA	NA	2E-02
	Zinc	4E-04	NA	4E-03	NA	NA	1E-03	NA	NA	NA	6E-03
WWC - Reach D	Aluminum	NA	NA	9E-01	NA	NA	7E-04	NA	NA	NA	9E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	8E-03	NA	1E+00	NA	NA	2E-03	NA	NA	NA	1E+00
	Barium	NA	NA	9E-02	NA	NA	3E-04	NA	NA	NA	9E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	2E-03	NA	NA	1E-04	NA	NA	NA	2E-03
	Chromium	NA	NA	5E-02	NA	NA	3E-03	NA	NA	NA	5E-02
	Copper	NA	NA	3E-02	NA	NA	4E-03	NA	NA	NA	3E-02
	Lead	NA	NA	4E-02	NA	NA	2E-05	NA	NA	NA	4E-02
	Manganese	NA	NA	2E-02	NA	NA	6E-05	NA	NA	NA	2E-02
	Mercury	NA	NA	2E-02	NA	NA	6E-05	NA	NA	NA	2E-02
	Molybdenum	NA	NA	8E-04	NA	NA	NA	NA	NA	NA	8E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	1E-02	NA	NA	6E-05	NA	NA	NA	1E-02
	Zinc	1E-03	NA	3E-03	NA	NA	1E-03	NA	NA	NA	6E-03

# APPENDIX L

## Cliff Swallow

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART B: HQ VALUES CALCULATED USING LOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
BFR - Reach A	Aluminum	NA	NA	9E-01	NA	NA	NA	NA	NA	NA	9E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	4E-04	NA	6E-03	NA	NA	NA	NA	NA	NA	6E-03
	Barium	NA	NA	1E-01	NA	NA	NA	NA	NA	NA	1E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	2E-03	NA	NA	NA	NA	NA	NA	2E-03
	Chromium	NA	NA	4E-02	NA	NA	NA	NA	NA	NA	4E-02
	Copper	NA	NA	1E-02	NA	NA	NA	NA	NA	NA	1E-02
	Lead	NA	NA	3E-02	NA	NA	NA	NA	NA	NA	3E-02
	Manganese	NA	NA	1E-02	NA	NA	NA	NA	NA	NA	1E-02
	Mercury	NA	NA	5E-04	NA	NA	NA	NA	NA	NA	5E-04
	Molybdenum	NA	NA	2E-03	NA	NA	NA	NA	NA	NA	2E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	2E-02	NA	NA	NA	NA	NA	NA	2E-02
	Zinc	3E-05	NA	3E-03	NA	NA	NA	NA	NA	NA	3E-03
BFR - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	1E-04	NA	NA	NA	NA	NA	NA	NA	NA	1E-04
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	3E-05	NA	NA	NA	NA	NA	NA	NA	NA	3E-05
SPC	Aluminum	NA	NA	3E-01	NA	NA	4E-04	NA	NA	NA	3E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	1E-04	NA	1E-02	NA	NA	3E-05	NA	NA	NA	1E-02
	Barium	NA	NA	7E-02	NA	NA	3E-04	NA	NA	NA	7E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	3E-03	NA	NA	1E-04	NA	NA	NA	3E-03
	Chromium	NA	NA	2E-02	NA	NA	8E-04	NA	NA	NA	2E-02
	Copper	NA	NA	4E-03	NA	NA	3E-03	NA	NA	NA	8E-03
	Lead	NA	NA	5E-02	NA	NA	1E-05	NA	NA	NA	5E-02
	Manganese	NA	NA	5E-03	NA	NA	3E-05	NA	NA	NA	5E-03
	Mercury	NA	NA	3E-02	NA	NA	6E-05	NA	NA	NA	3E-02
	Molybdenum	NA	NA	4E-04	NA	NA	NA	NA	NA	NA	4E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	7E-03	NA	NA	2E-05	NA	NA	NA	7E-03
	Zinc	3E-05	NA	1E-03	NA	NA	1E-03	NA	NA	NA	3E-03

# APPENDIX L

## Belted Kingfisher

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART A: HQ VALUES CALCULATED USING NOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
WWC - Reach A	Aluminum	NA	3E+00	NA	NA	NA	NA	NA	2E-02	NA	3E+00
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	3E-03	8E-01	NA	NA	NA	NA	NA	3E-02	NA	8E-01
	Barium	NA	2E-01	NA	NA	NA	NA	NA	3E-03	NA	2E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	3E-02	NA	NA	NA	NA	NA	6E-04	NA	3E-02
	Chromium	NA	3E-01	NA	NA	NA	NA	NA	2E-03	NA	3E-01
	Copper	NA	3E-02	NA	NA	NA	NA	NA	4E-04	NA	3E-02
	Lead	NA	5E-02	NA	NA	NA	NA	NA	1E-04	NA	5E-02
	Manganese	NA	5E-02	NA	NA	NA	NA	NA	5E-03	NA	5E-02
	Mercury	NA	6E-03	NA	NA	NA	NA	NA	NA	NA	6E-03
	Molybdenum	NA	2E-03	NA	NA	NA	NA	NA	NA	NA	2E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	3E-02	NA	NA	NA	NA	NA	2E-04	NA	3E-02
	Zinc	1E-02	1E-02	NA	NA	NA	NA	NA	1E-03	NA	3E-02
WWC - Reach B	Aluminum	NA	3E+00	NA	NA	NA	NA	NA	1E-02	NA	4E+00
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	4E-03	2E+00	NA	NA	NA	NA	NA	3E-03	NA	2E+00
	Barium	NA	4E-01	NA	NA	NA	NA	NA	4E-04	NA	4E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	6E-02	NA	NA	NA	NA	NA	8E-05	NA	6E-02
	Chromium	NA	4E-01	NA	NA	NA	NA	NA	2E-03	NA	4E-01
	Copper	NA	6E-02	NA	NA	NA	NA	NA	7E-04	NA	6E-02
	Lead	NA	8E-01	NA	NA	NA	NA	NA	1E-04	NA	8E-01
	Manganese	NA	5E-02	NA	NA	NA	NA	NA	2E-04	NA	5E-02
	Mercury	NA	1E-02	NA	NA	NA	NA	NA	NA	NA	1E-02
	Molybdenum	NA	4E-03	NA	NA	NA	NA	NA	NA	NA	4E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	5E-02	NA	NA	NA	NA	NA	1E-04	NA	5E-02
	Zinc	3E-02	2E-02	NA	NA	NA	NA	NA	4E-04	NA	5E-02
WWC - Reach C	Aluminum	NA	3E+00	NA	NA	NA	NA	NA	1E-02	5E-03	3E+00
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	2E-02	4E+00	NA	NA	NA	NA	NA	1E-02	5E-02	4E+00
	Barium	NA	2E-01	NA	NA	NA	NA	NA	6E-04	9E-04	2E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	4E-02	NA	NA	NA	NA	NA	1E-04	4E-04	4E-02
	Chromium	NA	2E-01	NA	NA	NA	NA	NA	2E-03	2E-02	3E-01
	Copper	NA	7E-02	NA	NA	NA	NA	NA	5E-04	2E-03	8E-02
	Lead	NA	1E-01	NA	NA	NA	NA	NA	2E-04	3E-03	1E-01
	Manganese	NA	4E-02	NA	NA	NA	NA	NA	2E-04	2E-04	4E-02
	Mercury	NA	2E-02	NA	NA	NA	NA	NA	1E-04	7E-03	3E-02
	Molybdenum	NA	3E-03	NA	NA	NA	NA	NA	NA	NA	3E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	4E-02	NA	NA	NA	NA	NA	1E-04	3E-04	4E-02
	Zinc	7E-04	1E-02	NA	NA	NA	NA	NA	4E-04	9E-03	2E-02
WWC - Reach D	Aluminum	NA	4E+00	NA	NA	NA	NA	NA	1E-02	2E-02	4E+00
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	3E-02	3E+00	NA	NA	NA	NA	NA	1E-02	2E-02	3E+00
	Barium	NA	2E-01	NA	NA	NA	NA	NA	7E-04	2E-03	2E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	4E-02	NA	NA	NA	NA	NA	1E-04	2E-03	4E-02
	Chromium	NA	2E-01	NA	NA	NA	NA	NA	2E-03	2E-02	3E-01
	Copper	NA	2E-02	NA	NA	NA	NA	NA	4E-04	1E-03	3E-02
	Lead	NA	5E-02	NA	NA	NA	NA	NA	1E-04	1E-04	5E-02
	Manganese	NA	4E-02	NA	NA	NA	NA	NA	1E-03	3E-03	4E-02
	Mercury	NA	9E-03	NA	NA	NA	NA	NA	2E-04	6E-03	2E-02
	Molybdenum	NA	2E-03	NA	NA	NA	NA	NA	NA	NA	2E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	6E-02	NA	NA	NA	NA	NA	2E-04	7E-04	6E-02
	Zinc	2E-03	1E-02	NA	NA	NA	NA	NA	4E-04	6E-03	2E-02

# APPENDIX L

## Belted Kingfisher

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART A: HQ VALUES CALCULATED USING NOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
BFR - Reach A	Aluminum	NA	2E+00	NA	NA	NA	NA	NA	NA	1E-01	2E+00
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	2E-03	4E-02	NA	NA	NA	NA	NA	NA	3E-03	5E-02
	Barium	NA	2E-01	NA	NA	NA	NA	NA	NA	5E-03	3E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	6E-02	NA	NA	NA	NA	NA	NA	1E-03	6E-02
	Chromium	NA	1E-01	NA	NA	NA	NA	NA	NA	2E-02	2E-01
	Copper	NA	1E-02	NA	NA	NA	NA	NA	NA	1E-03	1E-02
	Lead	NA	4E-02	NA	NA	NA	NA	NA	NA	5E-04	4E-02
	Manganese	NA	3E-02	NA	NA	NA	NA	NA	NA	7E-04	3E-02
	Mercury	NA	1E-03	NA	NA	NA	NA	NA	NA	6E-03	7E-03
	Molybdenum	NA	5E-03	NA	NA	NA	NA	NA	NA	NA	5E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	5E-02	NA	NA	NA	NA	NA	NA	1E-03	6E-02
	Zinc	5E-05	8E-03	NA	NA	NA	NA	NA	NA	8E-03	2E-02
BFR - Reach B	Aluminum	NA	3E+00	NA	NA	NA	NA	NA	7E-03	7E-02	3E+00
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	5E-04	5E+00	NA	NA	NA	NA	NA	8E-04	1E-02	5E+00
	Barium	NA	2E-01	NA	NA	NA	NA	NA	4E-04	3E-03	2E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	4E-02	NA	NA	NA	NA	NA	8E-05	1E-03	4E-02
	Chromium	NA	2E-01	NA	NA	NA	NA	NA	2E-03	2E-02	2E-01
	Copper	NA	2E-02	NA	NA	NA	NA	NA	3E-04	1E-03	2E-02
	Lead	NA	6E-02	NA	NA	NA	NA	NA	7E-05	3E-04	6E-02
	Manganese	NA	3E-02	NA	NA	NA	NA	NA	9E-04	1E-03	4E-02
	Mercury	NA	5E-03	NA	NA	NA	NA	NA	NA	8E-03	1E-02
	Molybdenum	NA	3E-03	NA	NA	NA	NA	NA	NA	NA	3E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	5E-02	NA	NA	NA	NA	NA	1E-04	1E-03	5E-02
	Zinc	5E-05	8E-03	NA	NA	NA	NA	NA	3E-04	1E-02	2E-02
SPC	Aluminum	NA	1E+00	NA	NA	NA	NA	NA	5E-03	1E-02	1E+00
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	5E-04	4E-02	NA	NA	NA	NA	NA	3E-04	1E-03	5E-02
	Barium	NA	1E-01	NA	NA	NA	NA	NA	5E-04	2E-03	1E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	1E-02	NA	NA	NA	NA	NA	3E-05	5E-04	1E-02
	Chromium	NA	9E-02	NA	NA	NA	NA	NA	2E-03	8E-02	2E-01
	Copper	NA	5E-03	NA	NA	NA	NA	NA	2E-04	8E-04	6E-03
	Lead	NA	4E-02	NA	NA	NA	NA	NA	1E-04	2E-04	4E-02
	Manganese	NA	8E-03	NA	NA	NA	NA	NA	8E-05	1E-04	8E-03
	Mercury	NA	1E-03	NA	NA	NA	NA	NA	1E-04	5E-03	7E-03
	Molybdenum	NA	9E-05	NA	NA	NA	NA	NA	NA	NA	9E-05
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	1E-02	NA	NA	NA	NA	NA	9E-05	6E-04	1E-02
	Zinc	5E-05	3E-03	NA	NA	NA	NA	NA	3E-04	9E-03	1E-02

# APPENDIX L

## Belted Kingfisher

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART B: HQ VALUES CALCULATED USING LOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
WWC - Reach A	Aluminum	NA	6E-01	NA	NA	NA	NA	NA	4E-03	NA	6E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	3E-04	9E-02	NA	NA	NA	NA	NA	4E-03	NA	9E-02
	Barium	NA	8E-02	NA	NA	NA	NA	NA	1E-03	NA	8E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	1E-03	NA	NA	NA	NA	NA	2E-05	NA	1E-03
	Chromium	NA	5E-02	NA	NA	NA	NA	NA	4E-04	NA	5E-02
	Copper	NA	2E-02	NA	NA	NA	NA	NA	2E-04	NA	2E-02
	Lead	NA	2E-02	NA	NA	NA	NA	NA	6E-05	NA	2E-02
	Manganese	NA	2E-02	NA	NA	NA	NA	NA	2E-03	NA	2E-02
	Mercury	NA	3E-03	NA	NA	NA	NA	NA	NA	NA	3E-03
	Molybdenum	NA	6E-04	NA	NA	NA	NA	NA	NA	NA	6E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	1E-02	NA	NA	NA	NA	NA	7E-05	NA	1E-02
	Zinc	4E-03	5E-03	NA	NA	NA	NA	NA	3E-04	NA	9E-03
WWC - Reach B	Aluminum	NA	7E-01	NA	NA	NA	NA	NA	2E-03	NA	7E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	5E-04	2E-01	NA	NA	NA	NA	NA	4E-04	NA	2E-01
	Barium	NA	2E-01	NA	NA	NA	NA	NA	2E-04	NA	2E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	2E-03	NA	NA	NA	NA	NA	3E-06	NA	2E-03
	Chromium	NA	8E-02	NA	NA	NA	NA	NA	4E-04	NA	8E-02
	Copper	NA	4E-02	NA	NA	NA	NA	NA	5E-04	NA	4E-02
	Lead	NA	4E-01	NA	NA	NA	NA	NA	5E-05	NA	4E-01
	Manganese	NA	2E-02	NA	NA	NA	NA	NA	7E-05	NA	2E-02
	Mercury	NA	5E-03	NA	NA	NA	NA	NA	NA	NA	5E-03
	Molybdenum	NA	1E-03	NA	NA	NA	NA	NA	NA	NA	1E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	2E-02	NA	NA	NA	NA	NA	3E-05	NA	2E-02
	Zinc	1E-02	7E-03	NA	NA	NA	NA	NA	1E-04	NA	2E-02
WWC - Reach C	Aluminum	NA	5E-01	NA	NA	NA	NA	NA	2E-03	9E-04	5E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	2E-03	5E-01	NA	NA	NA	NA	NA	2E-03	6E-03	5E-01
	Barium	NA	1E-01	NA	NA	NA	NA	NA	3E-04	5E-04	1E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	2E-03	NA	NA	NA	NA	NA	5E-06	2E-05	2E-03
	Chromium	NA	5E-02	NA	NA	NA	NA	NA	4E-04	4E-03	5E-02
	Copper	NA	5E-02	NA	NA	NA	NA	NA	3E-04	1E-03	5E-02
	Lead	NA	7E-02	NA	NA	NA	NA	NA	1E-04	2E-03	7E-02
	Manganese	NA	1E-02	NA	NA	NA	NA	NA	7E-05	6E-05	1E-02
	Mercury	NA	1E-02	NA	NA	NA	NA	NA	7E-05	3E-03	1E-02
	Molybdenum	NA	1E-03	NA	NA	NA	NA	NA	NA	NA	1E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	1E-02	NA	NA	NA	NA	NA	5E-05	1E-04	1E-02
	Zinc	2E-04	5E-03	NA	NA	NA	NA	NA	1E-04	3E-03	8E-03
WWC - Reach D	Aluminum	NA	8E-01	NA	NA	NA	NA	NA	3E-03	5E-03	8E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	4E-03	3E-01	NA	NA	NA	NA	NA	1E-03	2E-03	3E-01
	Barium	NA	9E-02	NA	NA	NA	NA	NA	3E-04	1E-03	9E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	1E-03	NA	NA	NA	NA	NA	4E-06	6E-05	2E-03
	Chromium	NA	5E-02	NA	NA	NA	NA	NA	4E-04	4E-03	5E-02
	Copper	NA	2E-02	NA	NA	NA	NA	NA	3E-04	6E-04	2E-02
	Lead	NA	3E-02	NA	NA	NA	NA	NA	7E-05	7E-05	3E-02
	Manganese	NA	1E-02	NA	NA	NA	NA	NA	3E-04	1E-03	1E-02
	Mercury	NA	5E-03	NA	NA	NA	NA	NA	1E-04	3E-03	8E-03
	Molybdenum	NA	8E-04	NA	NA	NA	NA	NA	NA	NA	8E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	2E-02	NA	NA	NA	NA	NA	6E-05	2E-04	2E-02
	Zinc	7E-04	3E-03	NA	NA	NA	NA	NA	1E-04	2E-03	6E-03

# APPENDIX L

## Belted Kingfisher

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART B: HQ VALUES CALCULATED USING LOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
BFR - Reach A	Aluminum	NA	4E-01	NA	NA	NA	NA	NA	NA	2E-02	5E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	2E-04	5E-03	NA	NA	NA	NA	NA	NA	4E-04	6E-03
	Barium	NA	1E-01	NA	NA	NA	NA	NA	NA	3E-03	1E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	2E-03	NA	NA	NA	NA	NA	NA	4E-05	2E-03
	Chromium	NA	3E-02	NA	NA	NA	NA	NA	NA	5E-03	3E-02
	Copper	NA	9E-03	NA	NA	NA	NA	NA	NA	7E-04	1E-02
	Lead	NA	2E-02	NA	NA	NA	NA	NA	NA	3E-04	2E-02
	Manganese	NA	9E-03	NA	NA	NA	NA	NA	NA	2E-04	9E-03
	Mercury	NA	6E-04	NA	NA	NA	NA	NA	NA	3E-03	4E-03
	Molybdenum	NA	2E-03	NA	NA	NA	NA	NA	NA	NA	2E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	2E-02	NA	NA	NA	NA	NA	NA	5E-04	2E-02
	Zinc	2E-05	3E-03	NA	NA	NA	NA	NA	NA	3E-03	5E-03
BFR - Reach B	Aluminum	NA	5E-01	NA	NA	NA	NA	NA	1E-03	1E-02	6E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	6E-05	5E-01	NA	NA	NA	NA	NA	9E-05	1E-03	5E-01
	Barium	NA	9E-02	NA	NA	NA	NA	NA	2E-04	1E-03	9E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	1E-03	NA	NA	NA	NA	NA	3E-06	4E-05	2E-03
	Chromium	NA	3E-02	NA	NA	NA	NA	NA	3E-04	5E-03	4E-02
	Copper	NA	1E-02	NA	NA	NA	NA	NA	2E-04	8E-04	1E-02
	Lead	NA	3E-02	NA	NA	NA	NA	NA	4E-05	2E-04	3E-02
	Manganese	NA	1E-02	NA	NA	NA	NA	NA	3E-04	4E-04	1E-02
	Mercury	NA	3E-03	NA	NA	NA	NA	NA	NA	4E-03	7E-03
	Molybdenum	NA	8E-04	NA	NA	NA	NA	NA	NA	NA	8E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	2E-02	NA	NA	NA	NA	NA	4E-05	3E-04	2E-02
	Zinc	2E-05	3E-03	NA	NA	NA	NA	NA	1E-04	4E-03	7E-03
SPC	Aluminum	NA	2E-01	NA	NA	NA	NA	NA	1E-03	3E-03	2E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	6E-05	5E-03	NA	NA	NA	NA	NA	3E-05	1E-04	5E-03
	Barium	NA	6E-02	NA	NA	NA	NA	NA	2E-04	8E-04	7E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	4E-04	NA	NA	NA	NA	NA	9E-07	2E-05	4E-04
	Chromium	NA	2E-02	NA	NA	NA	NA	NA	3E-04	2E-02	3E-02
	Copper	NA	3E-03	NA	NA	NA	NA	NA	1E-04	5E-04	4E-03
	Lead	NA	2E-02	NA	NA	NA	NA	NA	6E-05	1E-04	2E-02
	Manganese	NA	3E-03	NA	NA	NA	NA	NA	3E-05	4E-05	3E-03
	Mercury	NA	6E-04	NA	NA	NA	NA	NA	6E-05	3E-03	3E-03
	Molybdenum	NA	3E-05	NA	NA	NA	NA	NA	NA	NA	3E-05
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	4E-03	NA	NA	NA	NA	NA	3E-05	2E-04	4E-03
	Zinc	2E-05	9E-04	NA	NA	NA	NA	NA	1E-04	3E-03	4E-03

# APPENDIX L

## American Robin

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART A: HQ VALUES CALCULATED USING NOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
WWC - Reach A	Aluminum	NA	NA	2E+01	4E-02	NA	NA	2E-02	NA	NA	2E+01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	3E-03	NA	4E-03	1E-03	NA	NA	7E-01	NA	NA	7E-01
	Barium	NA	NA	2E+00	3E-02	NA	NA	2E-02	NA	NA	2E+00
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	1E-01	8E-03	NA	NA	7E-02	NA	NA	2E-01
	Chromium	NA	NA	1E+00	3E-03	NA	NA	3E-02	NA	NA	1E+00
	Copper	NA	NA	5E-02	1E-03	NA	NA	8E-03	NA	NA	6E-02
	Lead	NA	NA	3E-01	1E-03	NA	NA	2E-03	NA	NA	3E-01
	Manganese	NA	NA	1E-01	1E-02	NA	NA	1E-03	NA	NA	1E-01
	Mercury	NA	NA	2E-01	2E-03	NA	NA	2E-02	NA	NA	2E-01
	Molybdenum	NA	NA	3E-03	NA	NA	NA	NA	NA	NA	3E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	1E-01	6E-04	NA	NA	4E-03	NA	NA	1E-01
	Zinc	1E-02	NA	3E-02	1E-03	NA	NA	1E-02	NA	NA	5E-02
WWC - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	5E-03	NA	NA	NA	NA	NA	NA	NA	NA	5E-03
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	4E-02	NA	NA	NA	NA	NA	NA	NA	NA	4E-02
WWC - Reach C	Aluminum	NA	NA	2E+01	1E-02	NA	NA	3E-02	NA	NA	2E+01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	3E-02	NA	7E+01	2E-02	NA	NA	1E+00	NA	NA	8E+01
	Barium	NA	NA	1E+00	6E-03	NA	NA	6E-03	NA	NA	1E+00
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	2E-01	8E-03	NA	NA	1E-01	NA	NA	3E-01
	Chromium	NA	NA	1E+00	3E-03	NA	NA	3E-02	NA	NA	1E+00
	Copper	NA	NA	3E-01	2E-03	NA	NA	8E-03	NA	NA	3E-01
	Lead	NA	NA	6E-01	3E-04	NA	NA	9E-04	NA	NA	6E-01
	Manganese	NA	NA	3E-01	2E-03	NA	NA	1E-03	NA	NA	3E-01
	Mercury	NA	NA	3E-01	7E-04	NA	NA	8E-03	NA	NA	3E-01
	Molybdenum	NA	NA	2E-02	NA	NA	NA	NA	NA	NA	2E-02
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	2E-01	4E-04	NA	NA	9E-04	NA	NA	2E-01
	Zinc	8E-04	NA	6E-02	1E-03	NA	NA	1E-02	NA	NA	7E-02
WWC - Reach D	Aluminum	NA	NA	2E+01	8E-03	NA	NA	1E-01	NA	NA	2E+01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	4E-02	NA	5E+01	6E-03	NA	NA	1E+00	NA	NA	5E+01
	Barium	NA	NA	9E-01	1E-02	NA	NA	7E-03	NA	NA	9E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	3E-01	4E-03	NA	NA	1E-01	NA	NA	4E-01
	Chromium	NA	NA	1E+00	6E-03	NA	NA	4E-02	NA	NA	1E+00
	Copper	NA	NA	2E-01	1E-03	NA	NA	7E-03	NA	NA	2E-01
	Lead	NA	NA	4E-01	2E-04	NA	NA	2E-03	NA	NA	4E-01
	Manganese	NA	NA	4E-01	7E-03	NA	NA	3E-03	NA	NA	4E-01
	Mercury	NA	NA	2E-01	5E-04	NA	NA	1E-02	NA	NA	2E-01
	Molybdenum	NA	NA	1E-02	NA	NA	NA	NA	NA	NA	1E-02
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	2E-01	3E-04	NA	NA	2E-03	NA	NA	2E-01
	Zinc	3E-03	NA	4E-02	1E-03	NA	NA	1E-02	NA	NA	6E-02

# APPENDIX L

## American Robin

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART A: HQ VALUES CALCULATED USING NOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
BFR - Reach A	Aluminum	NA	NA	2E+01	NA	NA	NA	NA	NA	NA	2E+01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	2E-03	NA	2E-01	NA	NA	NA	NA	NA	NA	2E-01
	Barium	NA	NA	9E-01	NA	NA	NA	NA	NA	NA	9E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	2E-01	NA	NA	NA	NA	NA	NA	2E-01
	Chromium	NA	NA	9E-01	NA	NA	NA	NA	NA	NA	9E-01
	Copper	NA	NA	1E-01	NA	NA	NA	NA	NA	NA	1E-01
	Lead	NA	NA	3E-01	NA	NA	NA	NA	NA	NA	3E-01
	Manganese	NA	NA	1E-01	NA	NA	NA	NA	NA	NA	1E-01
	Mercury	NA	NA	5E-03	NA	NA	NA	NA	NA	NA	5E-03
	Molybdenum	NA	NA	2E-02	NA	NA	NA	NA	NA	NA	2E-02
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	2E-01	NA	NA	NA	NA	NA	NA	2E-01
	Zinc	6E-05	NA	5E-02	NA	NA	NA	NA	NA	NA	5E-02
BFR - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	7E-04	NA	NA	NA	NA	NA	NA	NA	NA	7E-04
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	6E-05	NA	NA	NA	NA	NA	NA	NA	NA	6E-05
SPC	Aluminum	NA	NA	8E+00	2E-02	NA	NA	NA	NA	NA	8E+00
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	7E-04	NA	5E-01	1E-03	NA	NA	NA	NA	NA	5E-01
	Barium	NA	NA	6E-01	1E-02	NA	NA	NA	NA	NA	7E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	4E-01	5E-03	NA	NA	NA	NA	NA	4E-01
	Chromium	NA	NA	5E-01	4E-03	NA	NA	NA	NA	NA	5E-01
	Copper	NA	NA	3E-02	1E-03	NA	NA	NA	NA	NA	3E-02
	Lead	NA	NA	4E-01	1E-03	NA	NA	NA	NA	NA	4E-01
	Manganese	NA	NA	7E-02	8E-04	NA	NA	NA	NA	NA	7E-02
	Mercury	NA	NA	3E-01	5E-04	NA	NA	NA	NA	NA	3E-01
	Molybdenum	NA	NA	5E-03	NA	NA	NA	NA	NA	NA	5E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	9E-02	4E-04	NA	NA	NA	NA	NA	9E-02
	Zinc	6E-05	NA	2E-02	1E-03	NA	NA	NA	NA	NA	2E-02

# APPENDIX L

## American Robin

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART B: HQ VALUES CALCULATED USING LOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
WWC - Reach A	Aluminum	NA	NA	5E+00	8E-03	NA	NA	3E-03	NA	NA	5E+00
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	4E-04	NA	5E-04	1E-04	NA	NA	8E-02	NA	NA	8E-02
	Barium	NA	NA	8E-01	1E-02	NA	NA	1E-02	NA	NA	9E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	4E-03	3E-04	NA	NA	2E-03	NA	NA	7E-03
	Chromium	NA	NA	2E-01	7E-04	NA	NA	5E-03	NA	NA	2E-01
	Copper	NA	NA	3E-02	9E-04	NA	NA	5E-03	NA	NA	4E-02
	Lead	NA	NA	2E-01	6E-04	NA	NA	1E-03	NA	NA	2E-01
	Manganese	NA	NA	4E-02	3E-03	NA	NA	4E-04	NA	NA	4E-02
	Mercury	NA	NA	8E-02	9E-04	NA	NA	1E-02	NA	NA	9E-02
	Molybdenum	NA	NA	1E-03	NA	NA	NA	NA	NA	NA	1E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	4E-02	2E-04	NA	NA	1E-03	NA	NA	4E-02
	Zinc	4E-03	NA	9E-03	4E-04	NA	NA	3E-03	NA	NA	2E-02

WWC - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	6E-04	NA	NA	NA	NA	NA	NA	NA	NA	6E-04
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	1E-02	NA	NA	NA	NA	NA	NA	NA	NA	1E-02

WWC - Reach C	Aluminum	NA	NA	4E+00	2E-03	NA	NA	6E-03	NA	NA	4E+00
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	3E-03	NA	9E+00	2E-03	NA	NA	1E-01	NA	NA	9E+00
	Barium	NA	NA	5E-01	3E-03	NA	NA	3E-03	NA	NA	5E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	8E-03	3E-04	NA	NA	4E-03	NA	NA	1E-02
	Chromium	NA	NA	2E-01	6E-04	NA	NA	7E-03	NA	NA	3E-01
	Copper	NA	NA	2E-01	1E-03	NA	NA	6E-03	NA	NA	2E-01
	Lead	NA	NA	3E-01	2E-04	NA	NA	4E-04	NA	NA	3E-01
	Manganese	NA	NA	1E-01	6E-04	NA	NA	4E-04	NA	NA	1E-01
	Mercury	NA	NA	1E-01	3E-04	NA	NA	4E-03	NA	NA	1E-01
	Molybdenum	NA	NA	7E-03	NA	NA	NA	NA	NA	NA	7E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	7E-02	1E-04	NA	NA	3E-04	NA	NA	7E-02
	Zinc	3E-04	NA	2E-02	4E-04	NA	NA	3E-03	NA	NA	2E-02

WWC - Reach D	Aluminum	NA	NA	4E+00	2E-03	NA	NA	2E-02	NA	NA	4E+00
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	5E-03	NA	6E+00	7E-04	NA	NA	2E-01	NA	NA	6E+00
	Barium	NA	NA	4E-01	7E-03	NA	NA	4E-03	NA	NA	4E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	1E-02	2E-04	NA	NA	4E-03	NA	NA	2E-02
	Chromium	NA	NA	2E-01	1E-03	NA	NA	9E-03	NA	NA	2E-01
	Copper	NA	NA	1E-01	9E-04	NA	NA	5E-03	NA	NA	1E-01
	Lead	NA	NA	2E-01	9E-05	NA	NA	1E-03	NA	NA	2E-01
	Manganese	NA	NA	1E-01	2E-03	NA	NA	1E-03	NA	NA	1E-01
	Mercury	NA	NA	8E-02	3E-04	NA	NA	5E-03	NA	NA	9E-02
	Molybdenum	NA	NA	4E-03	NA	NA	NA	NA	NA	NA	4E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	7E-02	1E-04	NA	NA	6E-04	NA	NA	7E-02
	Zinc	9E-04	NA	1E-02	4E-04	NA	NA	4E-03	NA	NA	2E-02

# APPENDIX L

## American Robin

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART B: HQ VALUES CALCULATED USING LOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
BFR - Reach A	Aluminum	NA	NA	4E+00	NA	NA	NA	NA	NA	NA	4E+00
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	2E-04	NA	3E-02	NA	NA	NA	NA	NA	NA	3E-02
	Barium	NA	NA	5E-01	NA	NA	NA	NA	NA	NA	5E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	9E-03	NA	NA	NA	NA	NA	NA	9E-03
	Chromium	NA	NA	2E-01	NA	NA	NA	NA	NA	NA	2E-01
	Copper	NA	NA	6E-02	NA	NA	NA	NA	NA	NA	6E-02
	Lead	NA	NA	1E-01	NA	NA	NA	NA	NA	NA	1E-01
	Manganese	NA	NA	5E-02	NA	NA	NA	NA	NA	NA	5E-02
	Mercury	NA	NA	2E-03	NA	NA	NA	NA	NA	NA	2E-03
	Molybdenum	NA	NA	7E-03	NA	NA	NA	NA	NA	NA	7E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	8E-02	NA	NA	NA	NA	NA	NA	8E-02
	Zinc	2E-05	NA	2E-02	NA	NA	NA	NA	NA	NA	2E-02
BFR - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	8E-05	NA	NA	NA	NA	NA	NA	NA	NA	8E-05
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	2E-05	NA	NA	NA	NA	NA	NA	NA	NA	2E-05
SPC	Aluminum	NA	NA	2E+00	3E-03	NA	NA	NA	NA	NA	2E+00
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	8E-05	NA	6E-02	1E-04	NA	NA	NA	NA	NA	6E-02
	Barium	NA	NA	3E-01	7E-03	NA	NA	NA	NA	NA	3E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	1E-02	2E-04	NA	NA	NA	NA	NA	1E-02
	Chromium	NA	NA	1E-01	7E-04	NA	NA	NA	NA	NA	1E-01
	Copper	NA	NA	2E-02	1E-03	NA	NA	NA	NA	NA	2E-02
	Lead	NA	NA	2E-01	7E-04	NA	NA	NA	NA	NA	2E-01
	Manganese	NA	NA	2E-02	3E-04	NA	NA	NA	NA	NA	2E-02
	Mercury	NA	NA	2E-01	3E-04	NA	NA	NA	NA	NA	2E-01
	Molybdenum	NA	NA	2E-03	NA	NA	NA	NA	NA	NA	2E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	3E-02	1E-04	NA	NA	NA	NA	NA	3E-02
	Zinc	2E-05	NA	7E-03	4E-04	NA	NA	NA	NA	NA	7E-03

# APPENDIX L

## American Kestrel

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART A: HQ VALUES CALCULATED USING NOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
WWC - Reach A	Aluminum	NA	NA	2E+00	NA	8E-02	2E-03	NA	NA	NA	2E+00
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	3E-03	NA	3E-04	NA	1E-03	4E-05	NA	NA	NA	4E-03
	Barium	NA	NA	1E-01	NA	6E-03	6E-04	NA	NA	NA	1E-01
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	7E-03	NA	2E-03	6E-04	NA	NA	NA	1E-02
	Chromium	NA	NA	6E-02	NA	2E-02	5E-03	NA	NA	NA	9E-02
	Copper	NA	NA	3E-03	NA	1E-03	2E-03	NA	NA	NA	7E-03
	Lead	NA	NA	2E-02	NA	1E-03	6E-05	NA	NA	NA	2E-02
	Manganese	NA	NA	7E-03	NA	3E-04	3E-04	NA	NA	NA	8E-03
	Mercury	NA	NA	1E-02	NA	3E-05	5E-05	NA	NA	NA	1E-02
	Molybdenum	NA	NA	2E-04	NA	NA	NA	NA	NA	NA	2E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	8E-03	NA	2E-04	7E-05	NA	NA	NA	8E-03
	Zinc	1E-02	NA	2E-03	NA	2E-03	2E-03	NA	NA	NA	2E-02
WWC - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	5E-03	NA	NA	NA	NA	NA	NA	NA	NA	5E-03
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	3E-02	NA	NA	NA	NA	NA	NA	NA	NA	3E-02
WWC - Reach C	Aluminum	NA	NA	1E+00	NA	1E-02	4E-03	NA	NA	NA	1E+00
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	2E-02	NA	5E+00	NA	7E-03	2E-03	NA	NA	NA	5E+00
	Barium	NA	NA	6E-02	NA	2E-03	2E-04	NA	NA	NA	7E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	1E-02	NA	2E-03	3E-03	NA	NA	NA	2E-02
	Chromium	NA	NA	8E-02	NA	2E-02	2E-02	NA	NA	NA	1E-01
	Copper	NA	NA	2E-02	NA	2E-03	3E-03	NA	NA	NA	2E-02
	Lead	NA	NA	4E-02	NA	2E-04	2E-05	NA	NA	NA	4E-02
	Manganese	NA	NA	2E-02	NA	1E-04	7E-05	NA	NA	NA	2E-02
	Mercury	NA	NA	2E-02	NA	8E-04	5E-05	NA	NA	NA	2E-02
	Molybdenum	NA	NA	1E-03	NA	NA	NA	NA	NA	NA	1E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	1E-02	NA	1E-04	2E-05	NA	NA	NA	1E-02
	Zinc	7E-04	NA	4E-03	NA	3E-03	2E-03	NA	NA	NA	9E-03
WWC - Reach D	Aluminum	NA	NA	1E+00	NA	3E-02	2E-03	NA	NA	NA	1E+00
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	4E-02	NA	3E+00	NA	6E-03	6E-03	NA	NA	NA	3E+00
	Barium	NA	NA	6E-02	NA	2E-03	2E-04	NA	NA	NA	6E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	2E-02	NA	2E-03	2E-03	NA	NA	NA	2E-02
	Chromium	NA	NA	7E-02	NA	2E-02	7E-03	NA	NA	NA	1E-01
	Copper	NA	NA	1E-02	NA	2E-03	3E-03	NA	NA	NA	2E-02
	Lead	NA	NA	2E-02	NA	3E-04	2E-05	NA	NA	NA	2E-02
	Manganese	NA	NA	2E-02	NA	1E-04	7E-05	NA	NA	NA	2E-02
	Mercury	NA	NA	1E-02	NA	7E-04	5E-05	NA	NA	NA	1E-02
	Molybdenum	NA	NA	8E-04	NA	NA	NA	NA	NA	NA	8E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	1E-02	NA	2E-04	7E-05	NA	NA	NA	1E-02
	Zinc	2E-03	NA	3E-03	NA	4E-03	2E-03	NA	NA	NA	1E-02

# APPENDIX L

## American Kestrel

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART A: HQ VALUES CALCULATED USING NOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
BFR - Reach A	Aluminum	NA	NA	1E+00	NA	NA	NA	NA	NA	NA	1E+00
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	2E-03	NA	2E-02	NA	NA	NA	NA	NA	NA	2E-02
	Barium	NA	NA	6E-02	NA	NA	NA	NA	NA	NA	6E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	2E-02	NA	NA	NA	NA	NA	NA	2E-02
	Chromium	NA	NA	6E-02	NA	NA	NA	NA	NA	NA	6E-02
	Copper	NA	NA	6E-03	NA	NA	NA	NA	NA	NA	6E-03
	Lead	NA	NA	2E-02	NA	NA	NA	NA	NA	NA	2E-02
	Manganese	NA	NA	9E-03	NA	NA	NA	NA	NA	NA	9E-03
	Mercury	NA	NA	3E-04	NA	NA	NA	NA	NA	NA	3E-04
	Molybdenum	NA	NA	1E-03	NA	NA	NA	NA	NA	NA	1E-03
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	2E-02	NA	NA	NA	NA	NA	NA	2E-02
	Zinc	5E-05	NA	3E-03	NA	NA	NA	NA	NA	NA	3E-03
BFR - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	6E-04	NA	NA	NA	NA	NA	NA	NA	NA	6E-04
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	5E-05	NA	NA	NA	NA	NA	NA	NA	NA	5E-05
SPC	Aluminum	NA	NA	5E-01	NA	2E-02	8E-04	NA	NA	NA	5E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	6E-04	NA	3E-02	NA	7E-04	1E-04	NA	NA	NA	4E-02
	Barium	NA	NA	4E-02	NA	3E-03	3E-04	NA	NA	NA	4E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	2E-02	NA	2E-03	2E-03	NA	NA	NA	3E-02
	Chromium	NA	NA	3E-02	NA	2E-02	2E-03	NA	NA	NA	5E-02
	Copper	NA	NA	2E-03	NA	2E-03	2E-03	NA	NA	NA	6E-03
	Lead	NA	NA	3E-02	NA	2E-03	1E-05	NA	NA	NA	3E-02
	Manganese	NA	NA	4E-03	NA	2E-04	3E-05	NA	NA	NA	5E-03
	Mercury	NA	NA	2E-02	NA	2E-03	5E-05	NA	NA	NA	2E-02
	Molybdenum	NA	NA	3E-04	NA	NA	NA	NA	NA	NA	3E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	6E-03	NA	2E-04	2E-05	NA	NA	NA	6E-03
	Zinc	5E-05	NA	1E-03	NA	3E-03	2E-03	NA	NA	NA	6E-03

# APPENDIX L

## American Kestrel

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART B: HQ VALUES CALCULATED USING LOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
WWC - Reach A	Aluminum	NA	NA	3E-01	NA	2E-02	4E-04	NA	NA	NA	3E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	3E-04	NA	3E-05	NA	1E-04	5E-06	NA	NA	NA	5E-04
	Barium	NA	NA	5E-02	NA	3E-03	3E-04	NA	NA	NA	6E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	3E-04	NA	7E-05	2E-05	NA	NA	NA	4E-04
	Chromium	NA	NA	1E-02	NA	4E-03	1E-03	NA	NA	NA	2E-02
	Copper	NA	NA	2E-03	NA	9E-04	2E-03	NA	NA	NA	5E-03
	Lead	NA	NA	1E-02	NA	5E-04	3E-05	NA	NA	NA	1E-02
	Manganese	NA	NA	2E-03	NA	9E-05	1E-04	NA	NA	NA	3E-03
	Mercury	NA	NA	5E-03	NA	2E-05	3E-05	NA	NA	NA	5E-03
	Molybdenum	NA	NA	6E-05	NA	NA	NA	NA	NA	NA	6E-05
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	3E-03	NA	7E-05	2E-05	NA	NA	NA	3E-03
	Zinc	4E-03	NA	6E-04	NA	8E-04	6E-04	NA	NA	NA	6E-03
WWC - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	5E-04	NA	NA	NA	NA	NA	NA	NA	NA	5E-04
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	1E-02	NA	NA	NA	NA	NA	NA	NA	NA	1E-02
WWC - Reach C	Aluminum	NA	NA	3E-01	NA	2E-03	7E-04	NA	NA	NA	3E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	3E-03	NA	6E-01	NA	8E-04	2E-04	NA	NA	NA	6E-01
	Barium	NA	NA	3E-02	NA	1E-03	1E-04	NA	NA	NA	3E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	5E-04	NA	6E-05	1E-04	NA	NA	NA	7E-04
	Chromium	NA	NA	2E-02	NA	3E-03	5E-03	NA	NA	NA	2E-02
	Copper	NA	NA	1E-02	NA	1E-03	2E-03	NA	NA	NA	2E-02
	Lead	NA	NA	2E-02	NA	1E-04	9E-06	NA	NA	NA	2E-02
	Manganese	NA	NA	7E-03	NA	5E-05	2E-05	NA	NA	NA	7E-03
	Mercury	NA	NA	9E-03	NA	4E-04	2E-05	NA	NA	NA	1E-02
	Molybdenum	NA	NA	4E-04	NA	NA	NA	NA	NA	NA	4E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	5E-03	NA	4E-05	7E-06	NA	NA	NA	5E-03
	Zinc	2E-04	NA	1E-03	NA	9E-04	6E-04	NA	NA	NA	3E-03
WWC - Reach D	Aluminum	NA	NA	3E-01	NA	6E-03	3E-04	NA	NA	NA	3E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	4E-03	NA	4E-01	NA	7E-04	7E-04	NA	NA	NA	4E-01
	Barium	NA	NA	3E-02	NA	1E-03	1E-04	NA	NA	NA	3E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	7E-04	NA	8E-05	6E-05	NA	NA	NA	8E-04
	Chromium	NA	NA	1E-02	NA	4E-03	1E-03	NA	NA	NA	2E-02
	Copper	NA	NA	9E-03	NA	2E-03	2E-03	NA	NA	NA	1E-02
	Lead	NA	NA	1E-02	NA	2E-04	8E-06	NA	NA	NA	1E-02
	Manganese	NA	NA	8E-03	NA	4E-05	2E-05	NA	NA	NA	8E-03
	Mercury	NA	NA	5E-03	NA	3E-04	2E-05	NA	NA	NA	6E-03
	Molybdenum	NA	NA	3E-04	NA	NA	NA	NA	NA	NA	3E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	4E-03	NA	5E-05	2E-05	NA	NA	NA	4E-03
	Zinc	8E-04	NA	9E-04	NA	1E-03	6E-04	NA	NA	NA	3E-03

# APPENDIX L

## American Kestrel

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART B: HQ VALUES CALCULATED USING LOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
BFR - Reach A	Aluminum	NA	NA	3E-01	NA	NA	NA	NA	NA	NA	3E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	2E-04	NA	2E-03	NA	NA	NA	NA	NA	NA	2E-03
	Barium	NA	NA	3E-02	NA	NA	NA	NA	NA	NA	3E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	6E-04	NA	NA	NA	NA	NA	NA	6E-04
	Chromium	NA	NA	1E-02	NA	NA	NA	NA	NA	NA	1E-02
	Copper	NA	NA	4E-03	NA	NA	NA	NA	NA	NA	4E-03
	Lead	NA	NA	8E-03	NA	NA	NA	NA	NA	NA	8E-03
	Manganese	NA	NA	3E-03	NA	NA	NA	NA	NA	NA	3E-03
	Mercury	NA	NA	2E-04	NA	NA	NA	NA	NA	NA	2E-04
	Molybdenum	NA	NA	5E-04	NA	NA	NA	NA	NA	NA	5E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	5E-03	NA	NA	NA	NA	NA	NA	5E-03
	Zinc	2E-05	NA	1E-03	NA	NA	NA	NA	NA	NA	1E-03
BFR - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	7E-05	NA	NA	NA	NA	NA	NA	NA	NA	7E-05
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	2E-05	NA	NA	NA	NA	NA	NA	NA	NA	2E-05
SPC	Aluminum	NA	NA	1E-01	NA	4E-03	2E-04	NA	NA	NA	1E-01
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	7E-05	NA	4E-03	NA	8E-05	1E-05	NA	NA	NA	4E-03
	Barium	NA	NA	2E-02	NA	2E-03	1E-04	NA	NA	NA	2E-02
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	8E-04	NA	6E-05	6E-05	NA	NA	NA	9E-04
	Chromium	NA	NA	6E-03	NA	3E-03	3E-04	NA	NA	NA	1E-02
	Copper	NA	NA	1E-03	NA	1E-03	1E-03	NA	NA	NA	4E-03
	Lead	NA	NA	1E-02	NA	1E-03	6E-06	NA	NA	NA	2E-02
	Manganese	NA	NA	1E-03	NA	5E-05	1E-05	NA	NA	NA	2E-03
	Mercury	NA	NA	1E-02	NA	1E-03	2E-05	NA	NA	NA	1E-02
	Molybdenum	NA	NA	1E-04	NA	NA	NA	NA	NA	NA	1E-04
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	2E-03	NA	7E-05	7E-06	NA	NA	NA	2E-03
	Zinc	2E-05	NA	4E-04	NA	1E-03	5E-04	NA	NA	NA	2E-03

# APPENDIX L

## Red Fox

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART A: HQ VALUES CALCULATED USING NOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
WWC - Reach A	Aluminum	NA	NA	3E+00	4E-03	8E-02	NA	NA	NA	NA	3E+00
	Antimony	NA	NA	8E-02	3E-04	1E-02	NA	NA	NA	NA	9E-02
	Arsenic	3E-03	NA	6E-04	2E-04	1E-03	NA	NA	NA	NA	5E-03
	Barium	NA	NA	8E-02	1E-03	2E-03	NA	NA	NA	NA	8E-02
	Beryllium	NA	NA	8E-04	2E-06	4E-06	NA	NA	NA	NA	8E-04
	Cadmium	NA	NA	7E-04	4E-05	1E-04	NA	NA	NA	NA	8E-04
	Chromium	NA	NA	9E-06	3E-08	2E-06	NA	NA	NA	NA	1E-05
	Copper	NA	NA	3E-03	8E-05	8E-04	NA	NA	NA	NA	4E-03
	Lead	NA	NA	2E-02	8E-05	7E-04	NA	NA	NA	NA	3E-02
	Manganese	NA	NA	1E-02	1E-03	3E-04	NA	NA	NA	NA	2E-02
	Mercury	NA	NA	2E-03	1E-05	3E-06	NA	NA	NA	NA	2E-03
	Molybdenum	NA	NA	2E-02	NA	NA	NA	NA	NA	NA	2E-02
	Thallium	NA	NA	7E-02	4E-03	1E-03	NA	NA	NA	NA	7E-02
	Vanadium	NA	NA	1E-02	6E-05	2E-04	NA	NA	NA	NA	1E-02
	Zinc	3E-03	NA	3E-04	1E-05	3E-04	NA	NA	NA	NA	3E-03
WWC - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	5E-03	NA	NA	NA	NA	NA	NA	NA	NA	5E-03
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	8E-03	NA	NA	NA	NA	NA	NA	NA	NA	8E-03
WWC - Reach C	Aluminum	NA	NA	2E+00	9E-04	1E-02	NA	NA	NA	NA	2E+00
	Antimony	NA	NA	2E-01	2E-04	1E-02	NA	NA	NA	NA	2E-01
	Arsenic	3E-02	NA	1E+01	2E-03	9E-03	NA	NA	NA	NA	1E+01
	Barium	NA	NA	5E-02	3E-04	9E-04	NA	NA	NA	NA	5E-02
	Beryllium	NA	NA	1E-04	2E-06	3E-06	NA	NA	NA	NA	1E-04
	Cadmium	NA	NA	1E-03	4E-05	9E-05	NA	NA	NA	NA	1E-03
	Chromium	NA	NA	1E-05	3E-08	1E-06	NA	NA	NA	NA	1E-05
	Copper	NA	NA	2E-02	9E-05	1E-03	NA	NA	NA	NA	2E-02
	Lead	NA	NA	4E-02	2E-05	2E-04	NA	NA	NA	NA	4E-02
	Manganese	NA	NA	4E-02	2E-04	2E-04	NA	NA	NA	NA	4E-02
	Mercury	NA	NA	3E-03	6E-06	6E-05	NA	NA	NA	NA	3E-03
	Molybdenum	NA	NA	1E-01	NA	NA	NA	NA	NA	NA	1E-01
	Thallium	NA	NA	3E-01	3E-03	1E-03	NA	NA	NA	NA	3E-01
	Vanadium	NA	NA	3E-02	4E-05	1E-04	NA	NA	NA	NA	3E-02
	Zinc	2E-04	NA	6E-04	1E-05	3E-04	NA	NA	NA	NA	1E-03
WWC - Reach D	Aluminum	NA	NA	2E+00	8E-04	3E-02	NA	NA	NA	NA	2E+00
	Antimony	NA	NA	2E-01	2E-04	1E-02	NA	NA	NA	NA	2E-01
	Arsenic	4E-02	NA	7E+00	8E-04	8E-03	NA	NA	NA	NA	7E+00
	Barium	NA	NA	4E-02	6E-04	9E-04	NA	NA	NA	NA	4E-02
	Beryllium	NA	NA	1E-04	1E-06	3E-06	NA	NA	NA	NA	1E-04
	Cadmium	NA	NA	2E-03	2E-05	1E-04	NA	NA	NA	NA	2E-03
	Chromium	NA	NA	1E-05	5E-08	1E-06	NA	NA	NA	NA	1E-05
	Copper	NA	NA	1E-02	7E-05	1E-03	NA	NA	NA	NA	1E-02
	Lead	NA	NA	3E-02	1E-05	2E-04	NA	NA	NA	NA	3E-02
	Manganese	NA	NA	5E-02	8E-04	1E-04	NA	NA	NA	NA	5E-02
	Mercury	NA	NA	2E-03	4E-06	6E-05	NA	NA	NA	NA	2E-03
	Molybdenum	NA	NA	9E-02	NA	NA	NA	NA	NA	NA	9E-02
	Thallium	NA	NA	3E-01	2E-03	1E-03	NA	NA	NA	NA	3E-01
	Vanadium	NA	NA	2E-02	3E-05	2E-04	NA	NA	NA	NA	2E-02
	Zinc	6E-04	NA	5E-04	1E-05	4E-04	NA	NA	NA	NA	1E-03

# APPENDIX L

## Red Fox

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART A: HQ VALUES CALCULATED USING NOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
BFR - Reach A	Aluminum	NA	NA	2E+00	NA	NA	NA	NA	NA	NA	2E+00
	Antimony	NA	NA	8E-03	NA	NA	NA	NA	NA	NA	8E-03
	Arsenic	2E-03	NA	3E-02	NA	NA	NA	NA	NA	NA	4E-02
	Barium	NA	NA	4E-02	NA	NA	NA	NA	NA	NA	4E-02
	Beryllium	NA	NA	2E-04	NA	NA	NA	NA	NA	NA	2E-04
	Cadmium	NA	NA	1E-03	NA	NA	NA	NA	NA	NA	1E-03
	Chromium	NA	NA	8E-06	NA	NA	NA	NA	NA	NA	8E-06
	Copper	NA	NA	6E-03	NA	NA	NA	NA	NA	NA	6E-03
	Lead	NA	NA	2E-02	NA	NA	NA	NA	NA	NA	2E-02
	Manganese	NA	NA	2E-02	NA	NA	NA	NA	NA	NA	2E-02
	Mercury	NA	NA	5E-05	NA	NA	NA	NA	NA	NA	5E-05
	Molybdenum	NA	NA	2E-01	NA	NA	NA	NA	NA	NA	2E-01
	Thallium	NA	NA	1E-01	NA	NA	NA	NA	NA	NA	1E-01
	Vanadium	NA	NA	3E-02	NA	NA	NA	NA	NA	NA	3E-02
	Zinc	1E-05	NA	6E-04	NA	NA	NA	NA	NA	NA	6E-04
BFR - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	7E-04	NA	NA	NA	NA	NA	NA	NA	NA	7E-04
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	1E-05	NA	NA	NA	NA	NA	NA	NA	NA	1E-05
SPC	Aluminum	NA	NA	8E-01	2E-03	2E-02	NA	NA	NA	NA	8E-01
	Antimony	NA	NA	1E-01	2E-04	1E-02	NA	NA	NA	NA	2E-01
	Arsenic	7E-04	NA	8E-02	1E-04	9E-04	NA	NA	NA	NA	8E-02
	Barium	NA	NA	3E-02	6E-04	1E-03	NA	NA	NA	NA	3E-02
	Beryllium	NA	NA	1E-04	2E-06	3E-06	NA	NA	NA	NA	1E-04
	Cadmium	NA	NA	2E-03	3E-05	9E-05	NA	NA	NA	NA	2E-03
	Chromium	NA	NA	4E-06	3E-08	1E-06	NA	NA	NA	NA	6E-06
	Copper	NA	NA	2E-03	8E-05	1E-03	NA	NA	NA	NA	3E-03
	Lead	NA	NA	3E-02	9E-05	2E-03	NA	NA	NA	NA	3E-02
	Manganese	NA	NA	9E-03	9E-05	2E-04	NA	NA	NA	NA	9E-03
	Mercury	NA	NA	3E-03	4E-06	2E-04	NA	NA	NA	NA	3E-03
	Molybdenum	NA	NA	4E-02	NA	NA	NA	NA	NA	NA	4E-02
	Thallium	NA	NA	1E-01	3E-03	1E-03	NA	NA	NA	NA	1E-01
	Vanadium	NA	NA	1E-02	4E-05	2E-04	NA	NA	NA	NA	1E-02
	Zinc	1E-05	NA	2E-04	1E-05	4E-04	NA	NA	NA	NA	6E-04

# APPENDIX L

## Red Fox

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART B: HQ VALUES CALCULATED USING LOAEL-BASED TRVs

Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
WWC - Reach A	Aluminum	NA	NA	5E-01	8E-04	2E-02	NA	NA	NA	NA	5E-01
	Antimony	NA	NA	3E-02	1E-04	4E-03	NA	NA	NA	NA	3E-02
	Arsenic	1E-03	NA	2E-04	5E-05	4E-04	NA	NA	NA	NA	2E-03
	Barium	NA	NA	3E-02	4E-04	8E-04	NA	NA	NA	NA	3E-02
	Beryllium	NA	NA	3E-04	8E-07	1E-06	NA	NA	NA	NA	3E-04
	Cadmium	NA	NA	4E-04	2E-05	5E-05	NA	NA	NA	NA	4E-04
	Chromium	NA	NA	3E-06	8E-09	5E-07	NA	NA	NA	NA	3E-06
	Copper	NA	NA	2E-03	5E-05	6E-04	NA	NA	NA	NA	3E-03
	Lead	NA	NA	1E-02	4E-05	3E-04	NA	NA	NA	NA	1E-02
	Manganese	NA	NA	4E-03	4E-04	1E-04	NA	NA	NA	NA	5E-03
	Mercury	NA	NA	5E-04	5E-06	1E-06	NA	NA	NA	NA	5E-04
	Molybdenum	NA	NA	9E-04	NA	NA	NA	NA	NA	NA	9E-04
	Thallium	NA	NA	2E-02	1E-03	3E-04	NA	NA	NA	NA	2E-02
	Vanadium	NA	NA	5E-03	2E-05	8E-05	NA	NA	NA	NA	5E-03
	Zinc	9E-04	NA	1E-04	5E-06	9E-05	NA	NA	NA	NA	1E-03

WWC - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	2E-03	NA	NA	NA	NA	NA	NA	NA	NA	2E-03
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	3E-03	NA	NA	NA	NA	NA	NA	NA	NA	3E-03

WWC - Reach C	Aluminum	NA	NA	5E-01	2E-04	2E-03	NA	NA	NA	NA	5E-01
	Antimony	NA	NA	6E-02	7E-05	4E-03	NA	NA	NA	NA	6E-02
	Arsenic	9E-03	NA	4E+00	7E-04	3E-03	NA	NA	NA	NA	4E+00
	Barium	NA	NA	2E-02	9E-05	3E-04	NA	NA	NA	NA	2E-02
	Beryllium	NA	NA	4E-05	6E-07	1E-06	NA	NA	NA	NA	4E-05
	Cadmium	NA	NA	7E-04	2E-05	4E-05	NA	NA	NA	NA	7E-04
	Chromium	NA	NA	4E-06	8E-09	5E-07	NA	NA	NA	NA	4E-06
	Copper	NA	NA	1E-02	6E-05	7E-04	NA	NA	NA	NA	1E-02
	Lead	NA	NA	2E-02	1E-05	8E-05	NA	NA	NA	NA	2E-02
	Manganese	NA	NA	1E-02	6E-05	5E-05	NA	NA	NA	NA	1E-02
	Mercury	NA	NA	9E-04	2E-06	2E-05	NA	NA	NA	NA	9E-04
	Molybdenum	NA	NA	6E-03	NA	NA	NA	NA	NA	NA	6E-03
	Thallium	NA	NA	1E-01	9E-04	4E-04	NA	NA	NA	NA	1E-01
	Vanadium	NA	NA	9E-03	1E-05	5E-05	NA	NA	NA	NA	9E-03
	Zinc	6E-05	NA	2E-04	4E-06	1E-04	NA	NA	NA	NA	4E-04

WWC - Reach D	Aluminum	NA	NA	5E-01	2E-04	6E-03	NA	NA	NA	NA	5E-01
	Antimony	NA	NA	7E-02	6E-05	4E-03	NA	NA	NA	NA	7E-02
	Arsenic	1E-02	NA	2E+00	3E-04	3E-03	NA	NA	NA	NA	2E+00
	Barium	NA	NA	1E-02	2E-04	3E-04	NA	NA	NA	NA	1E-02
	Beryllium	NA	NA	4E-05	5E-07	1E-06	NA	NA	NA	NA	4E-05
	Cadmium	NA	NA	9E-04	1E-05	6E-05	NA	NA	NA	NA	1E-03
	Chromium	NA	NA	3E-06	2E-08	5E-07	NA	NA	NA	NA	4E-06
	Copper	NA	NA	9E-03	5E-05	9E-04	NA	NA	NA	NA	1E-02
	Lead	NA	NA	1E-02	6E-06	1E-04	NA	NA	NA	NA	1E-02
	Manganese	NA	NA	1E-02	2E-04	4E-05	NA	NA	NA	NA	1E-02
	Mercury	NA	NA	5E-04	1E-06	2E-05	NA	NA	NA	NA	5E-04
	Molybdenum	NA	NA	4E-03	NA	NA	NA	NA	NA	NA	4E-03
	Thallium	NA	NA	1E-01	8E-04	3E-04	NA	NA	NA	NA	1E-01
	Vanadium	NA	NA	8E-03	1E-05	6E-05	NA	NA	NA	NA	8E-03
	Zinc	2E-04	NA	2E-04	4E-06	1E-04	NA	NA	NA	NA	5E-04

# APPENDIX L

## Red Fox

### CALCULATION OF HQ VALUES

Hazard Quotient values greater than 1E+00 are shaded.

#### PART B: HQ VALUES CALCULATED USING LOAEL-BASED TRVs

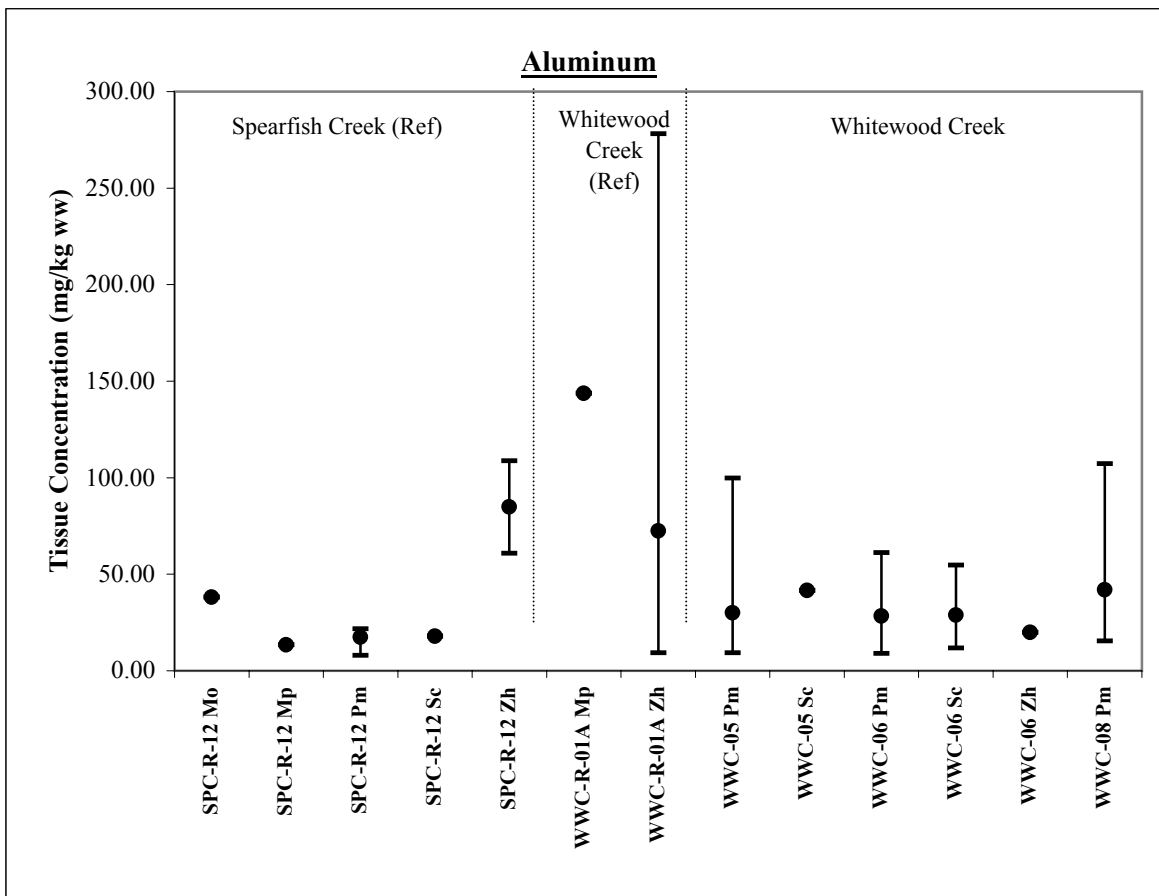
Station	COPC	Surface Water (Total)	Sediment	Soil - Flood Plain (Total)	Plants	Small Mammals	Terrestrial Invertebrates	Soil Invertebrates	Benthic Invertebrates	Fish	Total HI
BFR - Reach A	Aluminum	NA	NA	4E-01	NA	NA	NA	NA	NA	NA	4E-01
	Antimony	NA	NA	3E-03	NA	NA	NA	NA	NA	NA	3E-03
	Arsenic	7E-04	NA	1E-02	NA	NA	NA	NA	NA	NA	1E-02
	Barium	NA	NA	1E-02	NA	NA	NA	NA	NA	NA	1E-02
	Beryllium	NA	NA	5E-05	NA	NA	NA	NA	NA	NA	5E-05
	Cadmium	NA	NA	7E-04	NA	NA	NA	NA	NA	NA	7E-04
	Chromium	NA	NA	3E-06	NA	NA	NA	NA	NA	NA	3E-06
	Copper	NA	NA	4E-03	NA	NA	NA	NA	NA	NA	4E-03
	Lead	NA	NA	1E-02	NA	NA	NA	NA	NA	NA	1E-02
	Manganese	NA	NA	6E-03	NA	NA	NA	NA	NA	NA	6E-03
	Mercury	NA	NA	2E-05	NA	NA	NA	NA	NA	NA	2E-05
	Molybdenum	NA	NA	7E-03	NA	NA	NA	NA	NA	NA	7E-03
	Thallium	NA	NA	4E-02	NA	NA	NA	NA	NA	NA	4E-02
	Vanadium	NA	NA	1E-02	NA	NA	NA	NA	NA	NA	1E-02
	Zinc	4E-06	NA	2E-04	NA	NA	NA	NA	NA	NA	2E-04
BFR - Reach B	Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Antimony	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Arsenic	2E-04	NA	NA	NA	NA	NA	NA	NA	NA	2E-04
	Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Beryllium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Cadmium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Copper	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Molybdenum	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Thallium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Zinc	4E-06	NA	NA	NA	NA	NA	NA	NA	NA	4E-06
SPC	Aluminum	NA	NA	2E-01	3E-04	4E-03	NA	NA	NA	NA	2E-01
	Antimony	NA	NA	5E-02	7E-05	4E-03	NA	NA	NA	NA	5E-02
	Arsenic	2E-04	NA	3E-02	4E-05	3E-04	NA	NA	NA	NA	3E-02
	Barium	NA	NA	1E-02	2E-04	5E-04	NA	NA	NA	NA	1E-02
	Beryllium	NA	NA	3E-05	5E-07	1E-06	NA	NA	NA	NA	4E-05
	Cadmium	NA	NA	1E-03	1E-05	4E-05	NA	NA	NA	NA	1E-03
	Chromium	NA	NA	1E-06	9E-09	4E-07	NA	NA	NA	NA	2E-06
	Copper	NA	NA	1E-03	6E-05	7E-04	NA	NA	NA	NA	2E-03
	Lead	NA	NA	2E-02	4E-05	8E-04	NA	NA	NA	NA	2E-02
	Manganese	NA	NA	3E-03	3E-05	6E-05	NA	NA	NA	NA	3E-03
	Mercury	NA	NA	1E-03	1E-06	6E-05	NA	NA	NA	NA	1E-03
	Molybdenum	NA	NA	2E-03	NA	NA	NA	NA	NA	NA	2E-03
	Thallium	NA	NA	4E-02	9E-04	4E-04	NA	NA	NA	NA	4E-02
	Vanadium	NA	NA	4E-03	1E-05	7E-05	NA	NA	NA	NA	4E-03
	Zinc	4E-06	NA	8E-05	4E-06	1E-04	NA	NA	NA	NA	2E-04

## **APPENDIX M**

### **SUMMARY OF SMALL MAMMAL TISSUE CONCENTRATIONS**

# **Appendix M** **Summary of Small Mammal Tissue Concentrations by Location**




## *Ecological Risk Assessment* *Whitewood Creek, Lead, South Dakota*



**Species:**

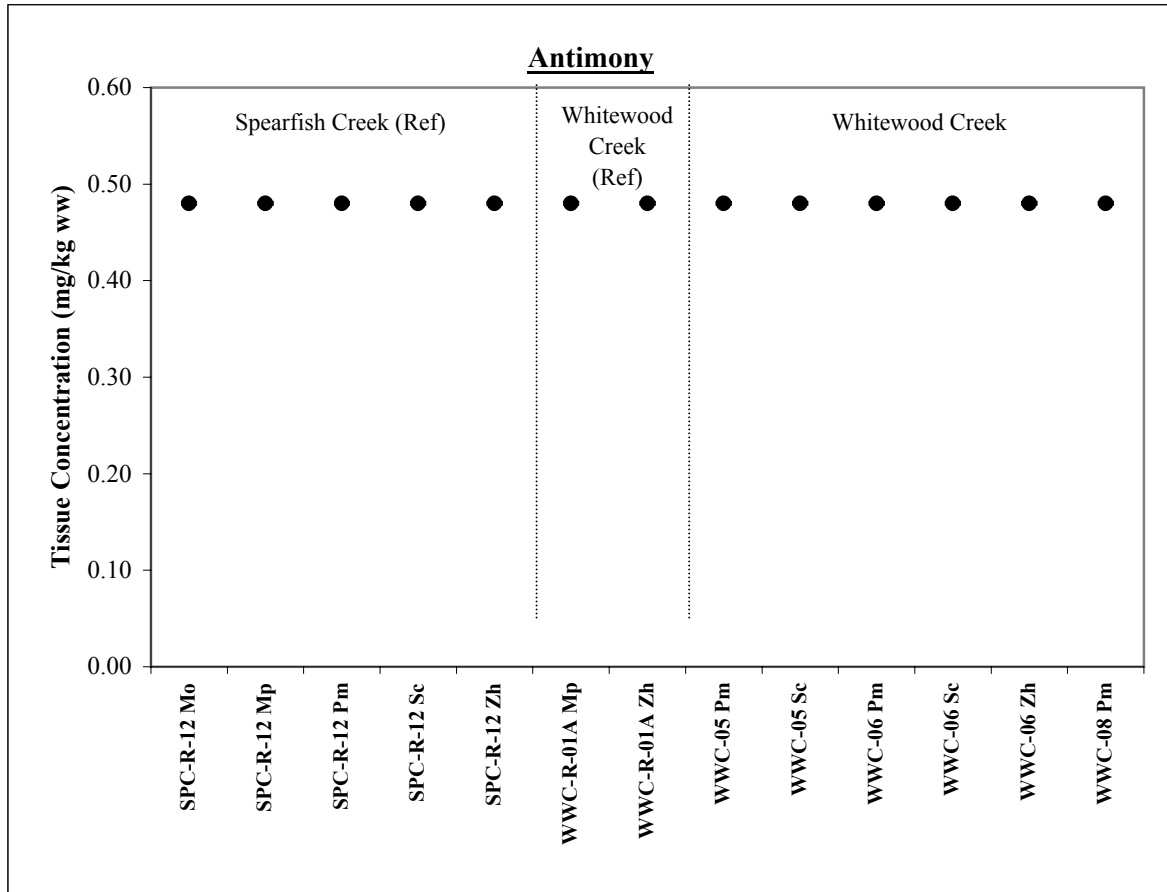
Mo - Prairie Vole (*Microtus ochrogaster*)  
 Mp - Meadow Vole (*Microtus pennsylvanicus*)  
 Pm - Deer Mouse (*Peromyscus maniculatus*)  
 Sc - Masked Shrew (*Sorex cinereus*)  
 Zh - Meadow Jumping Mouse (*Zapus hudsonius*)

**Legend:**

 ← Maximum Conc  
 ← Average Conc  
 ← Minimum Conc

# **Appendix M** **Summary of Small Mammal Tissue Concentrations by Location**

## *Ecological Risk Assessment* *Whitewood Creek, Lead, South Dakota*



**Species:**

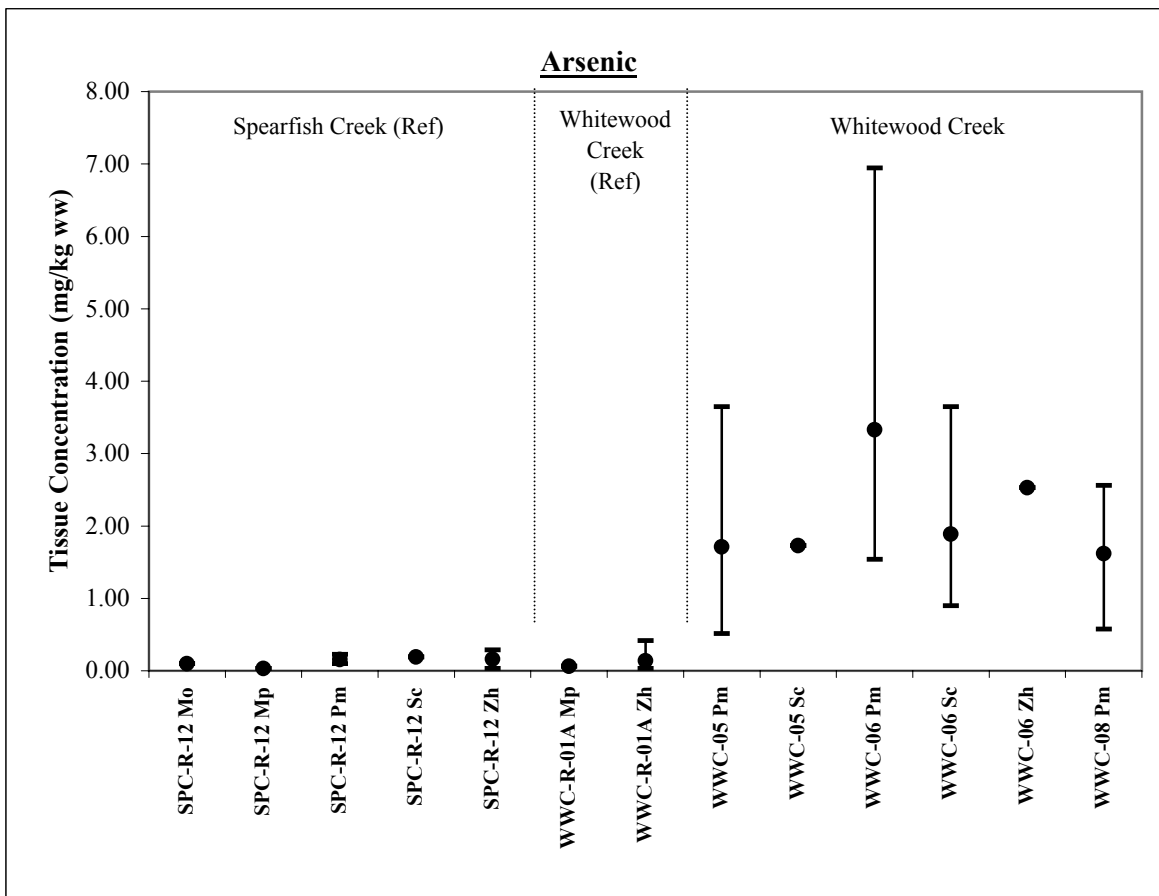
- Mo - Prairie Vole (*Microtus ochrogaster*)
- Mp - Meadow Vole (*Microtus pennsylvanicus*)
- Pm - Deer Mouse (*Peromyscus maniculatus*)
- Sc - Masked Shrew (*Sorex cinereus*)
- Zh - Meadow Jumping Mouse (*Zapus hudsonius*)

**Legend:**

- Maximum Conc
- Average Conc
- Minimum Conc

# **Appendix M** **Summary of Small Mammal Tissue Concentrations by Location**

## *Ecological Risk Assessment* *Whitewood Creek, Lead, South Dakota*



**Species:**

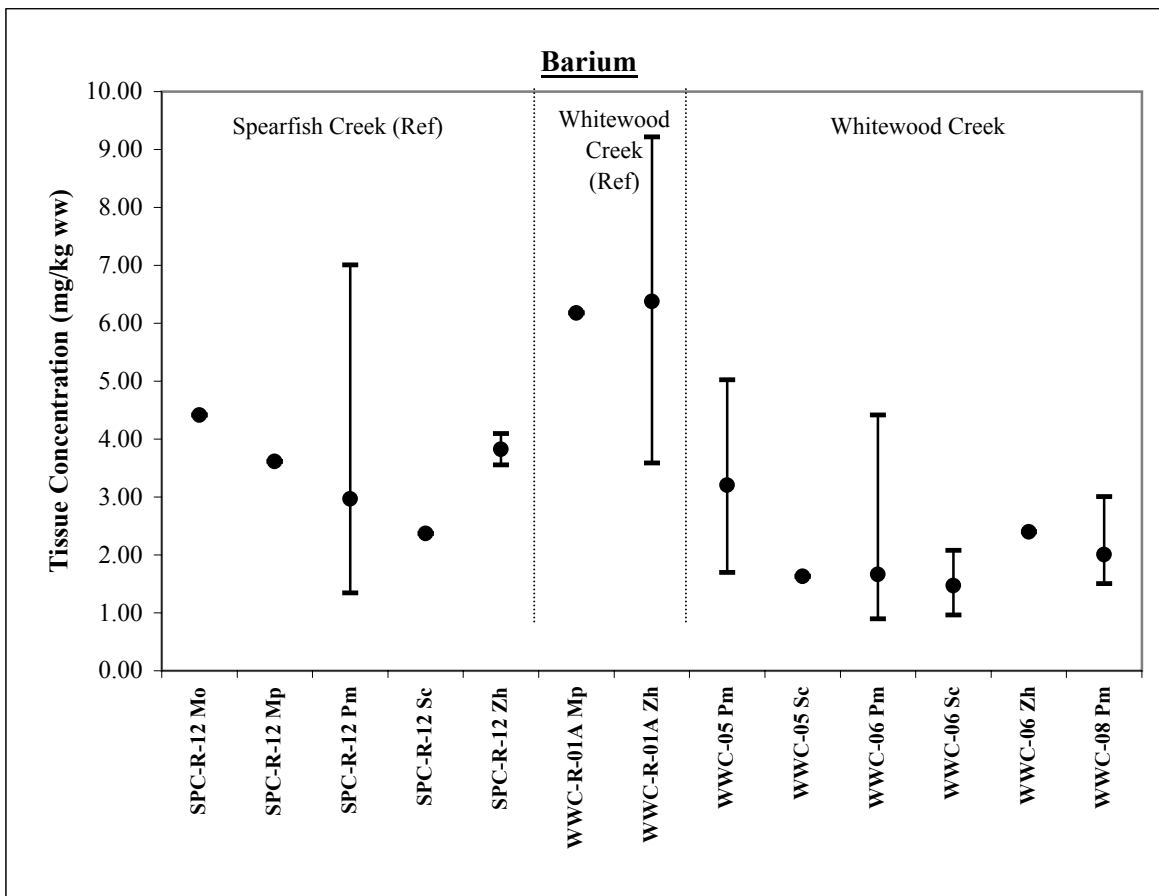
Mo - Prairie Vole (*Microtus ochrogaster*)  
 Mp - Meadow Vole (*Microtus pennsylvanicus*)  
 Pm - Deer Mouse (*Peromyscus maniculatus*)  
 Sc - Masked Shrew (*Sorex cinereus*)  
 Zh - Meadow Jumping Mouse (*Zapus hudsonius*)

**Legend:**

Maximum Conc  
 Average Conc  
 Minimum Conc

# **Appendix M** **Summary of Small Mammal Tissue Concentrations by Location**


## *Ecological Risk Assessment* *Whitewood Creek, Lead, South Dakota*



**Species:**

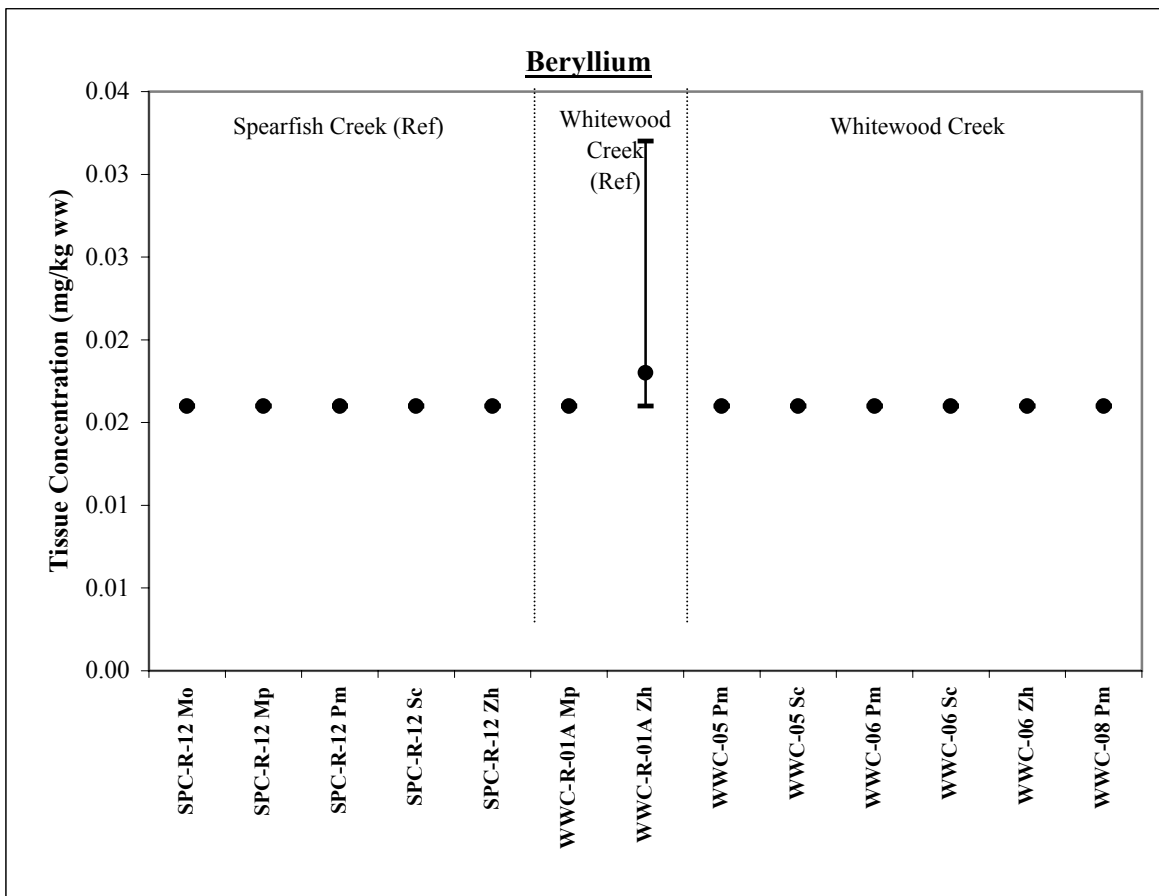
Mo - Prairie Vole (*Microtus ochrogaster*)  
 Mp - Meadow Vole (*Microtus pennsylvanicus*)  
 Pm - Deer Mouse (*Peromyscus maniculatus*)  
 Sc - Masked Shrew (*Sorex cinereus*)  
 Zh - Meadow Jumping Mouse (*Zapus hudsonius*)

**Legend:**

 ← Maximum Conc  
 ← Average Conc  
 ← Minimum Conc

# **Appendix M** **Summary of Small Mammal Tissue Concentrations by Location**

## *Ecological Risk Assessment* *Whitewood Creek, Lead, South Dakota*



**Species:**

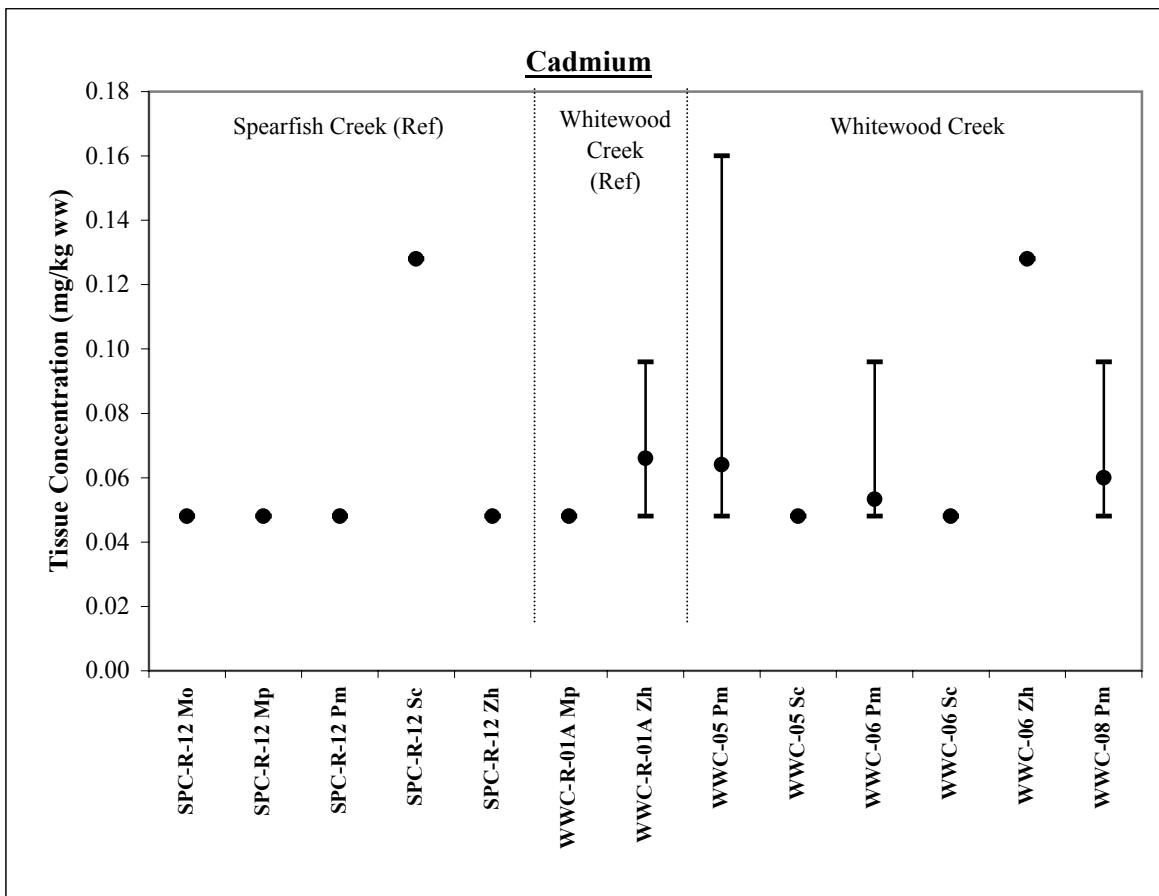
- Mo - Prairie Vole (*Microtus ochrogaster*)
- Mp - Meadow Vole (*Microtus pennsylvanicus*)
- Pm - Deer Mouse (*Peromyscus maniculatus*)
- Sc - Masked Shrew (*Sorex cinereus*)
- Zh - Meadow Jumping Mouse (*Zapus hudsonius*)

**Legend:**

- Maximum Conc
- Average Conc
- Minimum Conc

# **Appendix M** **Summary of Small Mammal Tissue Concentrations by Location**

## *Ecological Risk Assessment* *Whitewood Creek, Lead, South Dakota*



**Species:**

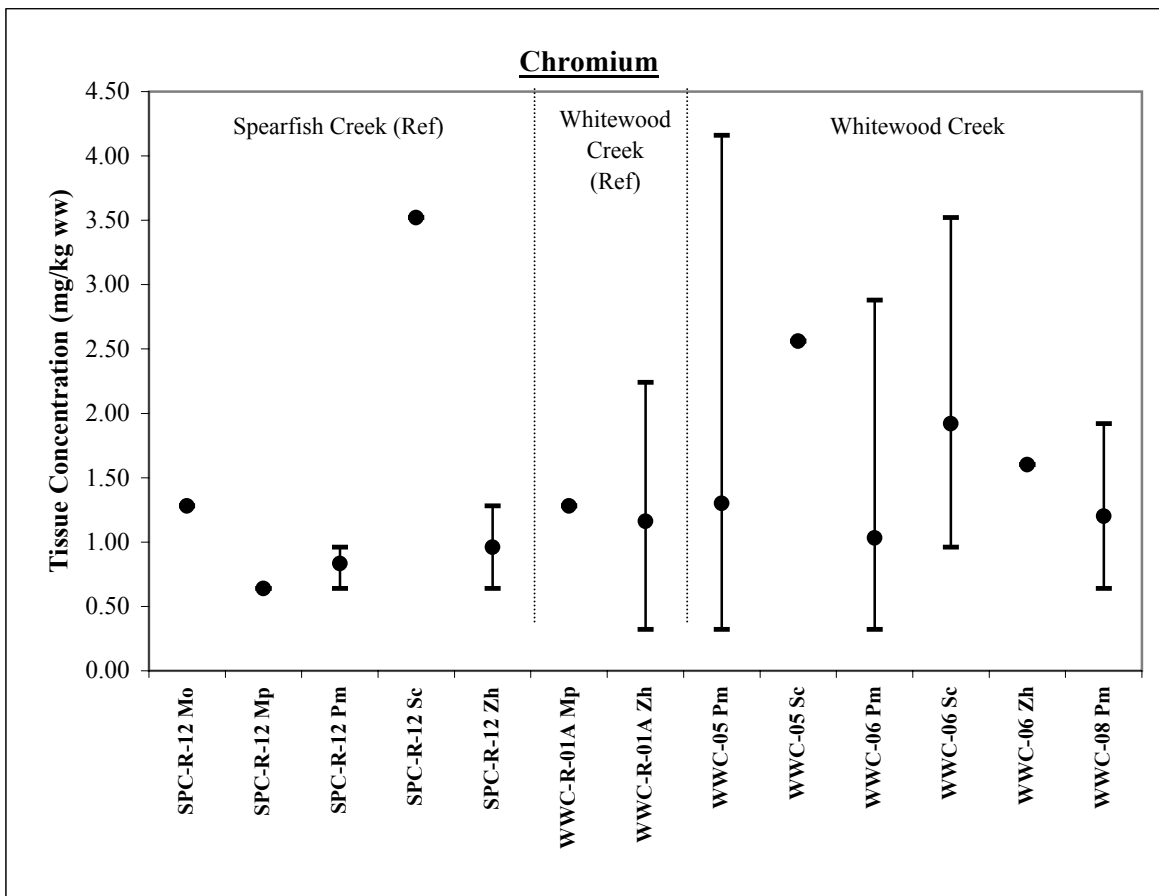
- Mo - Prairie Vole (*Microtus ochrogaster*)
- Mp - Meadow Vole (*Microtus pennsylvanicus*)
- Pm - Deer Mouse (*Peromyscus maniculatus*)
- Sc - Masked Shrew (*Sorex cinereus*)
- Zh - Meadow Jumping Mouse (*Zapus hudsonius*)

**Legend:**

- Maximum Conc
- Average Conc
- Minimum Conc

# **Appendix M** **Summary of Small Mammal Tissue Concentrations by Location**

## *Ecological Risk Assessment* *Whitewood Creek, Lead, South Dakota*



**Species:**

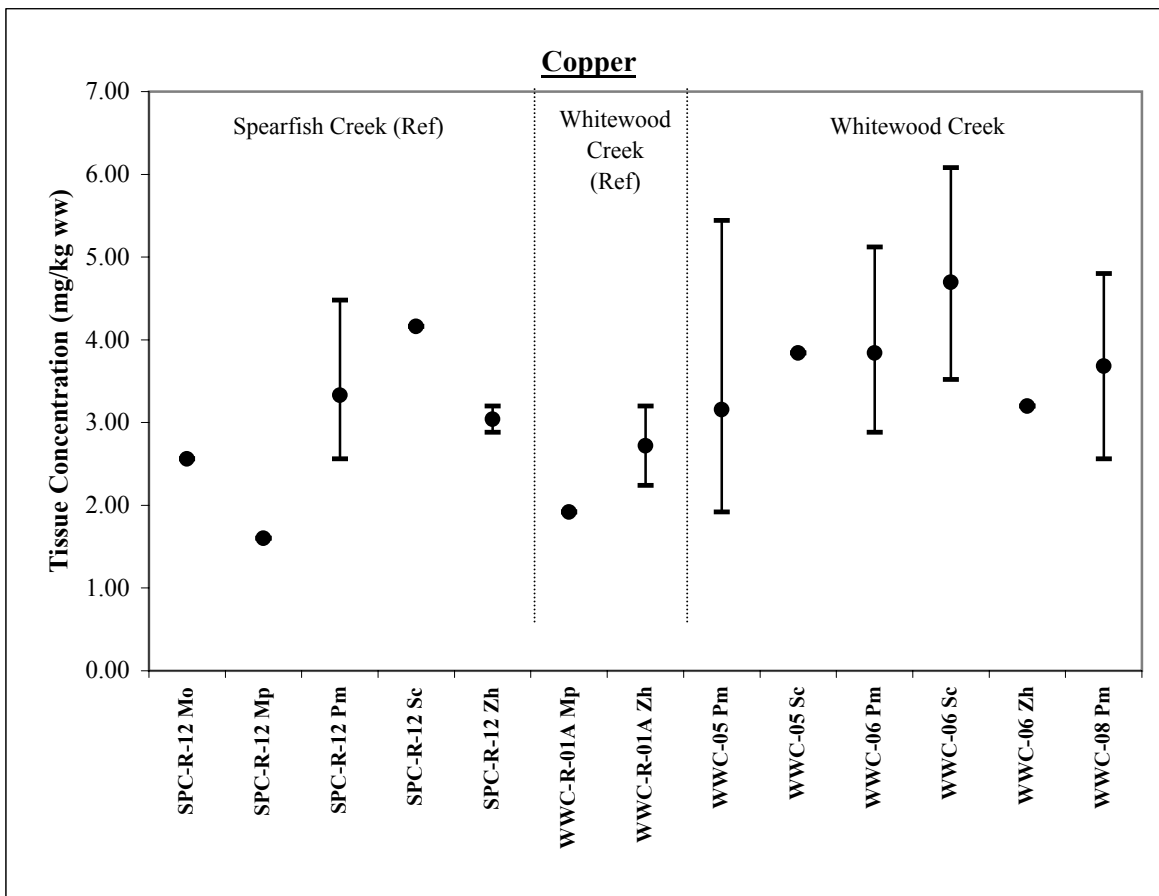
Mo - Prairie Vole (*Microtus ochrogaster*)  
 Mp - Meadow Vole (*Microtus pennsylvanicus*)  
 Pm - Deer Mouse (*Peromyscus maniculatus*)  
 Sc - Masked Shrew (*Sorex cinereus*)  
 Zh - Meadow Jumping Mouse (*Zapus hudsonius*)

**Legend:**

Maximum Conc  
 Average Conc  
 Minimum Conc

# **Appendix M** **Summary of Small Mammal Tissue Concentrations by Location**

## *Ecological Risk Assessment* *Whitewood Creek, Lead, South Dakota*



**Species:**

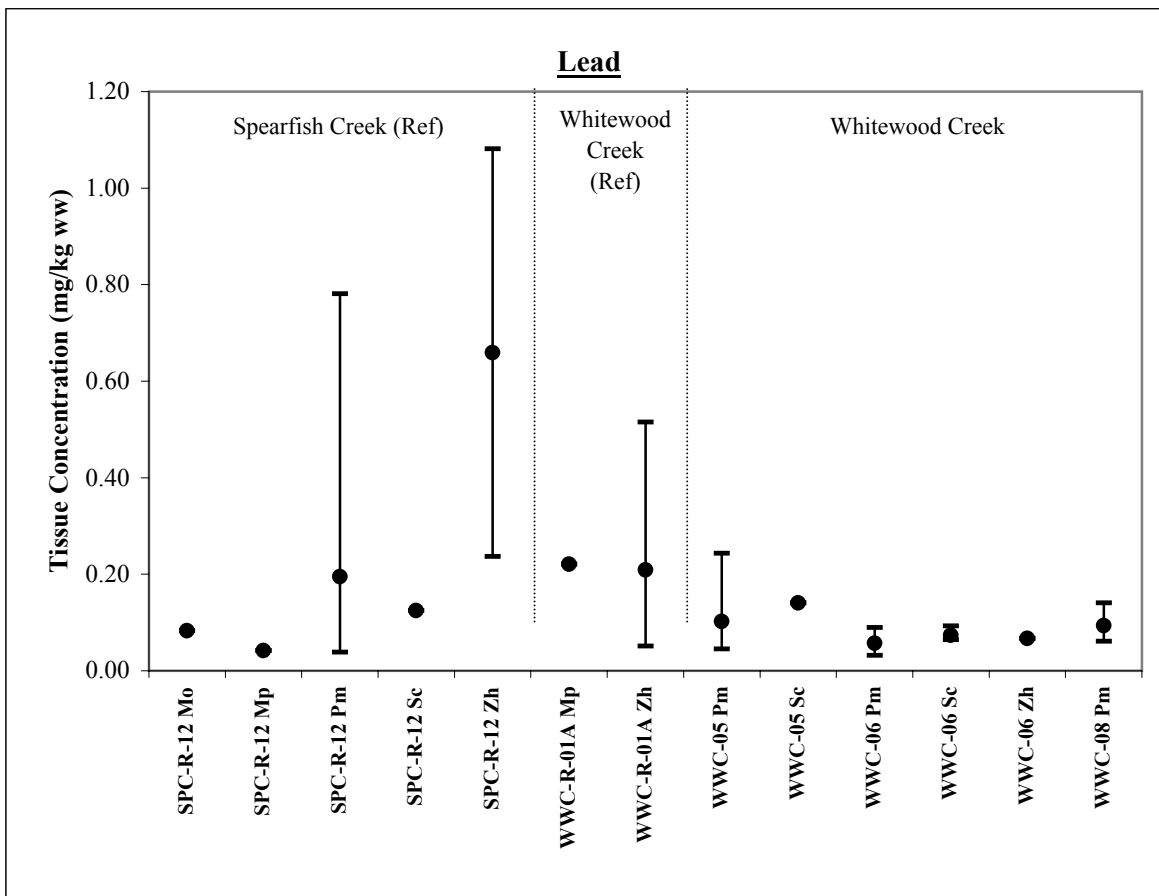
- Mo - Prairie Vole (*Microtus ochrogaster*)
- Mp - Meadow Vole (*Microtus pennsylvanicus*)
- Pm - Deer Mouse (*Peromyscus maniculatus*)
- Sc - Masked Shrew (*Sorex cinereus*)
- Zh - Meadow Jumping Mouse (*Zapus hudsonius*)

**Legend:**

- Maximum Conc
- Average Conc
- Minimum Conc

# **Appendix M** **Summary of Small Mammal Tissue Concentrations by Location**

## *Ecological Risk Assessment* *Whitewood Creek, Lead, South Dakota*



**Species:**

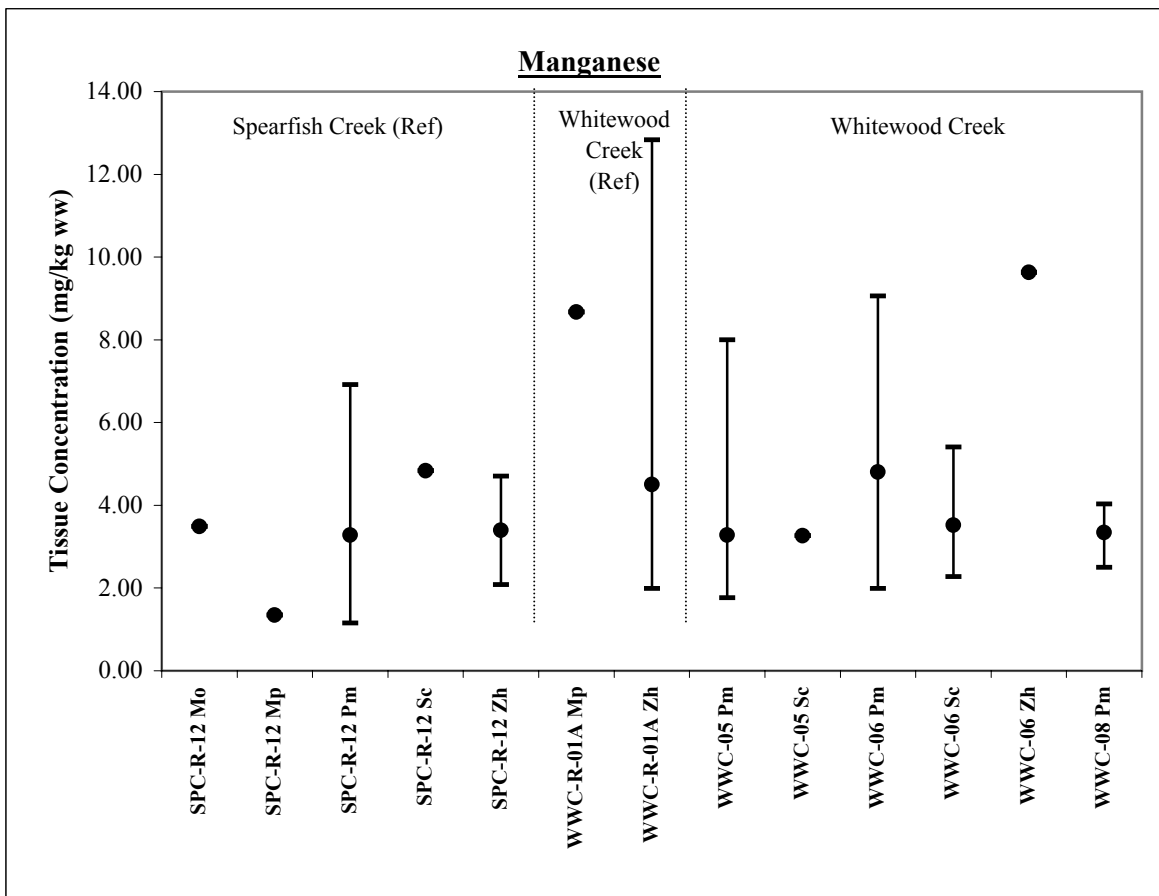
- Mo - Prairie Vole (*Microtus ochrogaster*)
- Mp - Meadow Vole (*Microtus pennsylvanicus*)
- Pm - Deer Mouse (*Peromyscus maniculatus*)
- Sc - Masked Shrew (*Sorex cinereus*)
- Zh - Meadow Jumping Mouse (*Zapus hudsonius*)

**Legend:**

- Maximum Conc
- Average Conc
- Minimum Conc

# **Appendix M** **Summary of Small Mammal Tissue Concentrations by Location**

## *Ecological Risk Assessment* *Whitewood Creek, Lead, South Dakota*



**Species:**

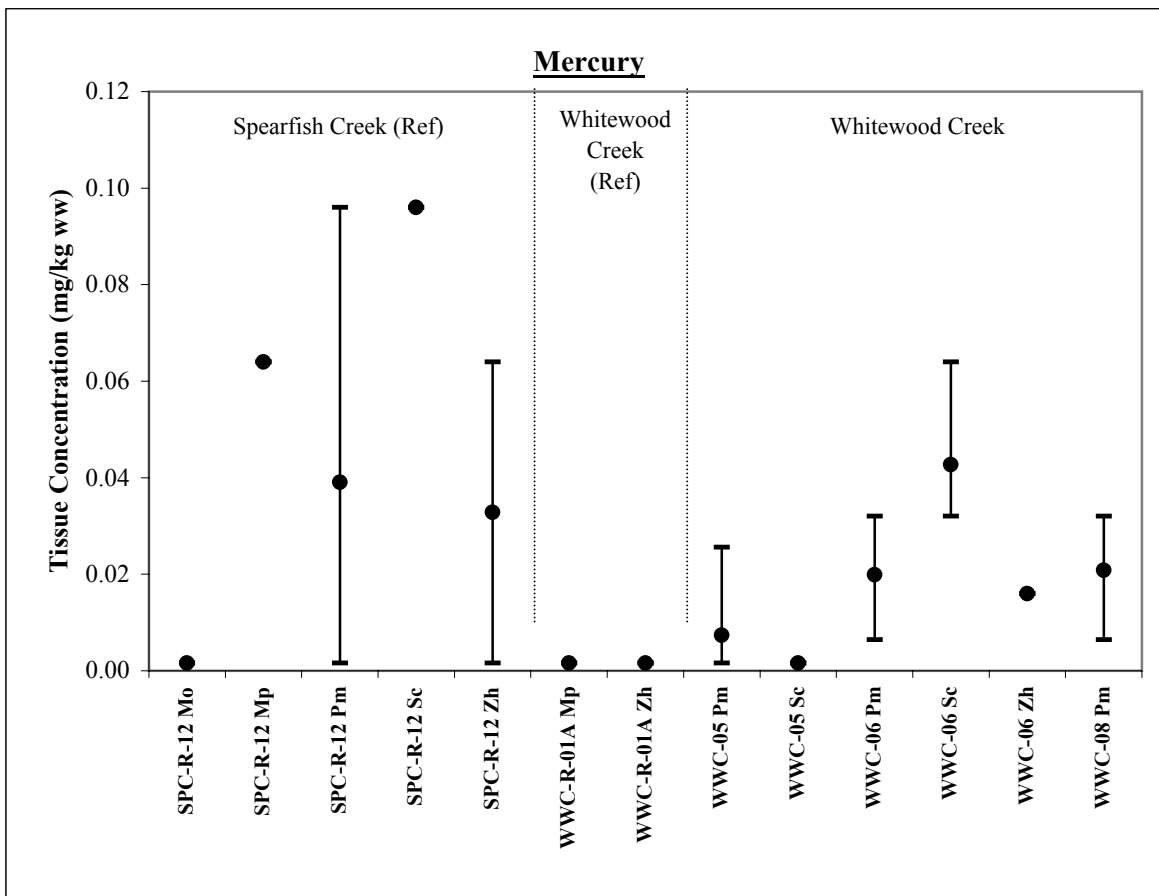
Mo - Prairie Vole (*Microtus ochrogaster*)  
 Mp - Meadow Vole (*Microtus pennsylvanicus*)  
 Pm - Deer Mouse (*Peromyscus maniculatus*)  
 Sc - Masked Shrew (*Sorex cinereus*)  
 Zh - Meadow Jumping Mouse (*Zapus hudsonius*)

**Legend:**

Maximum Conc  
 Average Conc  
 Minimum Conc

# **Appendix M** **Summary of Small Mammal Tissue Concentrations by Location**

## *Ecological Risk Assessment* *Whitewood Creek, Lead, South Dakota*



**Species:**

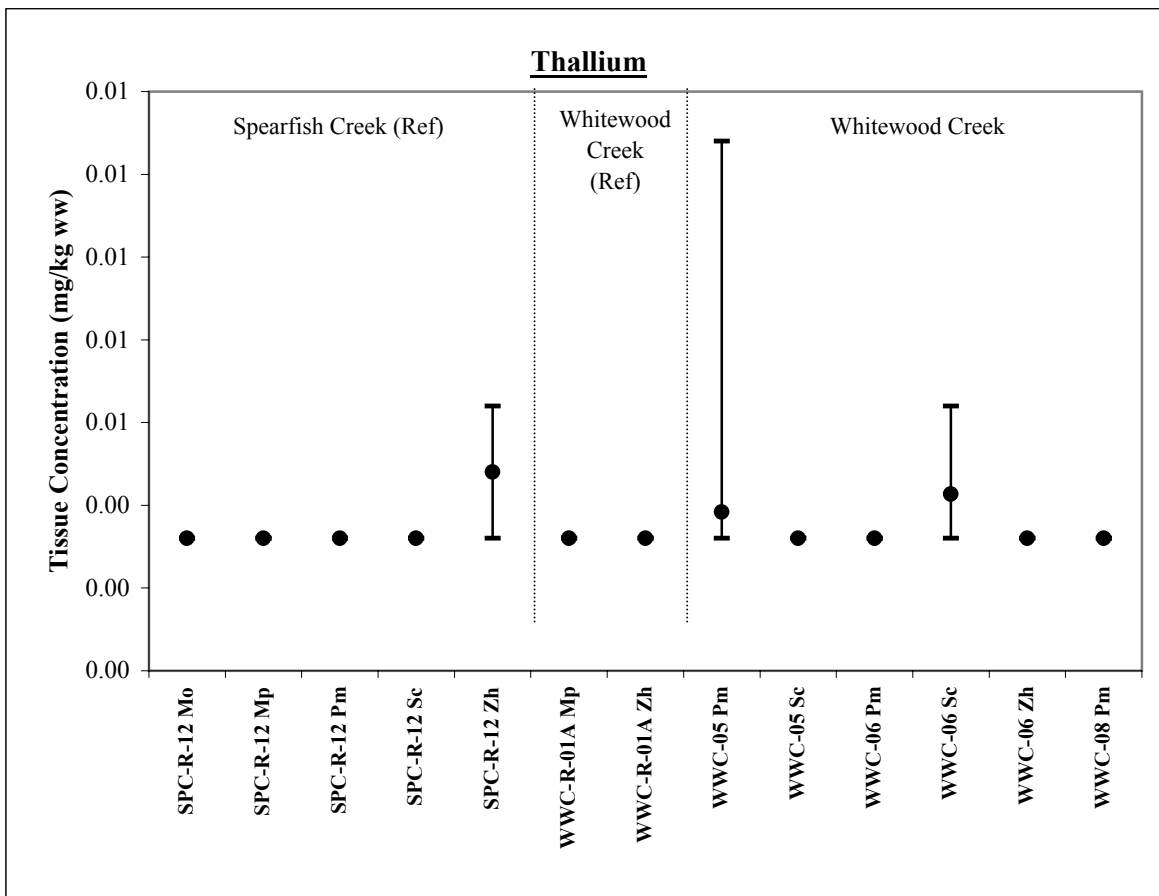
Mo - Prairie Vole (*Microtus ochrogaster*)  
Mp - Meadow Vole (*Microtus pennsylvanicus*)  
Pm - Deer Mouse (*Peromyscus maniculatus*)  
Sc - Masked Shrew (*Sorex cinereus*)  
Zh - Meadow Jumping Mouse (*Zapus hudsonius*)

**Legend:**

Maximum Conc  
 Average Conc  
 Minimum Conc

# **Appendix M** **Summary of Small Mammal Tissue Concentrations by Location**

## *Ecological Risk Assessment* *Whitewood Creek, Lead, South Dakota*



**Species:**

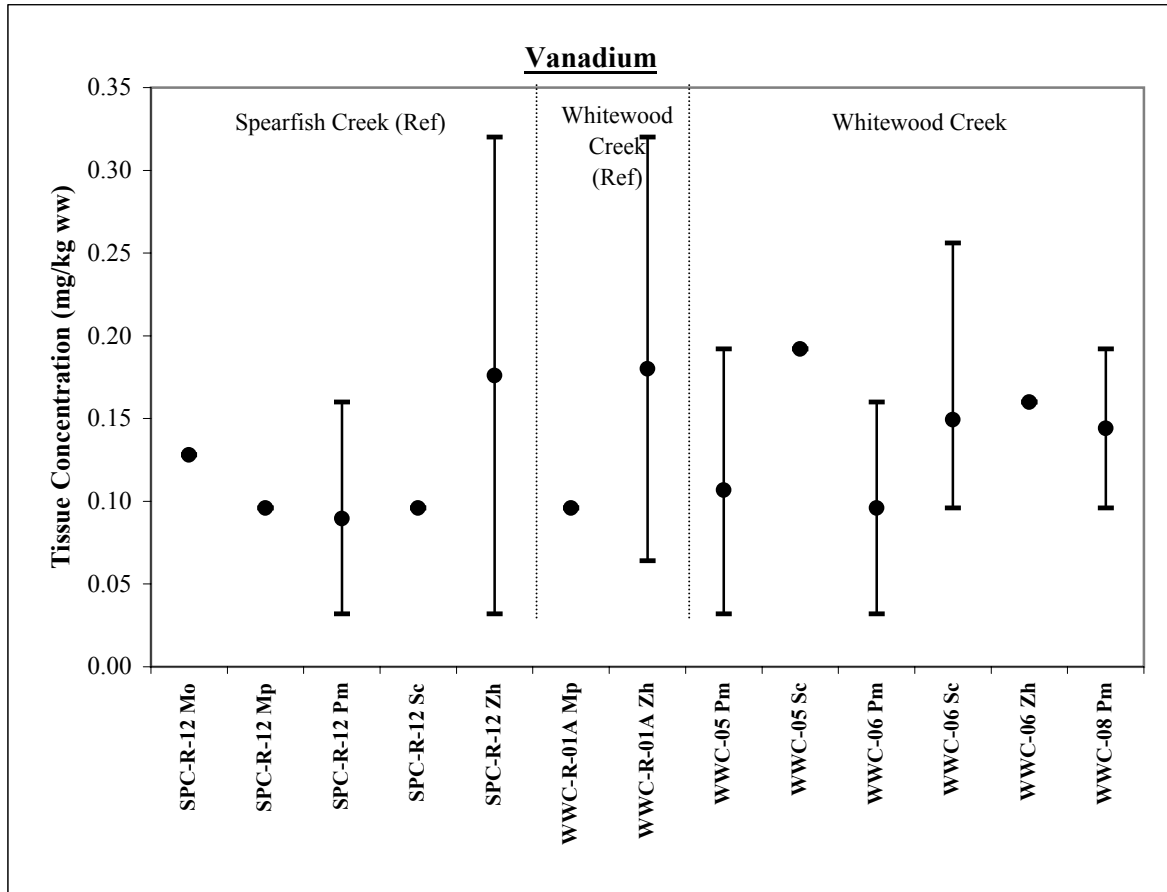
Mo - Prairie Vole (*Microtus ochrogaster*)  
 Mp - Meadow Vole (*Microtus pennsylvanicus*)  
 Pm - Deer Mouse (*Peromyscus maniculatus*)  
 Sc - Masked Shrew (*Sorex cinereus*)  
 Zh - Meadow Jumping Mouse (*Zapus hudsonius*)

**Legend:**

Maximum Conc  
 Average Conc  
 Minimum Conc

# **Appendix M** **Summary of Small Mammal Tissue Concentrations by Location**

## *Ecological Risk Assessment* *Whitewood Creek, Lead, South Dakota*



Species:

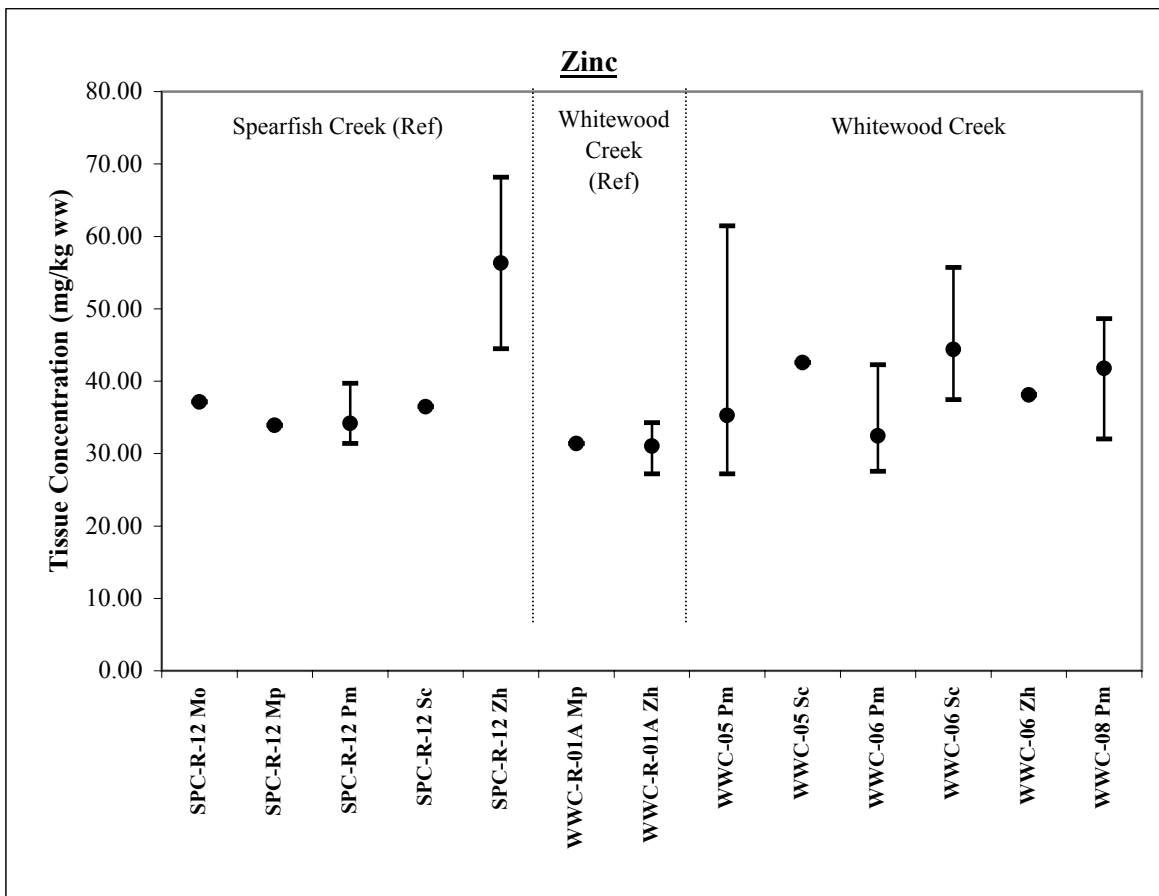
Mo - Prairie Vole (*Microtus ochrogaster*)  
 Mp - Meadow Vole (*Microtus pennsylvanicus*)  
 Pm - Deer Mouse (*Peromyscus maniculatus*)  
 Sc - Masked Shrew (*Sorex cinereus*)  
 Zh - Meadow Jumping Mouse (*Zapus hudsonius*)

Legend:

← Maximum Conc  
 ← Average Conc  
 ← Minimum Conc

# **Appendix M** **Summary of Small Mammal Tissue Concentrations by Location**



## *Ecological Risk Assessment* *Whitewood Creek, Lead, South Dakota*



**Species:**

Mo - Prairie Vole (*Microtus ochrogaster*)  
 Mp - Meadow Vole (*Microtus pennsylvanicus*)  
 Pm - Deer Mouse (*Peromyscus maniculatus*)  
 Sc - Masked Shrew (*Sorex cinereus*)  
 Zh - Meadow Jumping Mouse (*Zapus hudsonius*)

**Legend:**

 ← Maximum Conc  
 ← Average Conc  
 ← Minimum Conc